SAFETY GUIDELINES HANDBOOK

Second Edition

SOURCE EVALUATION SOCIETY

www.sesnews.org

DEDICATION

The Source Evaluation Society dedicates this* Safety Manual *to the memory of

Matthew S. DeVito (1955-2000)

Matt was an avid supporter of safety measures for those in the source sampling field, and urged his fellow testers to follow safe testing practices.

DISCLAIMER

Each company or individual is responsible for their own safety. This *Safety Manual* is INTENDED SOLELY AS AN INFORMATIONAL RESOURCE FOR INDIVIDUALS evaluating testing locations. SES PROVIDES NO WARRANTIES OR REPRESENTATION AS TO THE CONTENTS, RESULTS OF USE OR ADHERENCE TO THE INFORMATION CONTAINED HEREIN. Individuals, in conjunction with site supervisors, may use the enclosed information to make informed decisions BUT SHOULD MAKE INDEPENDENT JUDGEMENT APPROPRIATE FOR A GIVEN SITUATION. Any OSHA requirements supercede the information contained in this manual.

PREFACE

This manual is a compilation of submissions from different members of the Safety Committee. The editorial committee attempted to make the format as uniform as possible, but as can be seen, there are still variations in style and content. Some of the topics overlap or re-state the problems and solutions. We urge you to read the manual carefully and completely, then select the most appropriate solution for your need. No effort has been made to elect one area over another.

This manual is intended to be a living document. If you, as the reader, notice any errors or would care to add to any section or write an additional sections, we urge you to contact the Chairman of the Safety Committee - Michael W. Hartman, or the SES Secretary.

ACKNOWLEDGMENT

The SES wishes to acknowledge the efforts of the following without whom this manual would not have been possible. Their efforts were entirely without pay or any type of remuneration, and this document should serve as a testament to their selfless contributions to the stack sampling community. We wish we could do more than to say "Thank You" on behalf of the SES members and future members.

Contributors

Tony Blanton
Larry Cottone
Robert (Bob) Davis
Chuck Duncan
Tony Eggleston
David Elam
Bob Finken
Mike Harley
Mike Hartman
Don Henning
John Hosenfeld
Joel Iserman
David Law
James Meador
Gene Riley
Dave Rossman
Howard Schiff
Gary Schoening
James Serne
John Smith
Charles Sneeringer
William (Bill) Timpone

I would like to personally thank Gail Westlin for her contributions of time and expertise. She was responsible for the compilation, organization, typing and re-typing of the *Manual*, as well as constantly reminding me and the committee of due dates.

We would like to thank all the contributors who volunteered their time to review this *Manual*.

Table of Contents

Appendices:

Access to a Stack Testing Location

There are basically three means of permanent access to a stack testing location. They are elevators, permanent ladders and stairs. In general, it is a good idea to have elevators, ladders, and stairs inspected by the facility's safety representative and certified for worthiness prior to the test program. All three present some risk, so we will discuss each one.

ELEVATORS

Elevators are great when they work. The main problem is when they quit working while someone is in it. For that reason everyone who takes the elevator should be familiar with the emergency procedures and know where the key is hidden for the lock on the emergency lever control. Also, it is important that there is always some means of communication (preferably a radio) in the elevator so that you can call for help if you need it.

Another great thing about elevators is that they provide the fastest and easiest way to get your equipment on the stack. It is important that you know what the load limit is and that you don't exceed it. A significant hazard exists when someone tries to transport long probes in the elevator. This is usually accomplished by opening the roof hatch and overriding the interlock safety switch then sticking the probes up through the hatch. This should ***never*** be done under any circumstances. Aside from the fact that overriding the interlock switch is illegal, a very dangerous situation occurs when the probes are not kept perfectly vertical. Most elevators are powered by a traveling cable but some use a buss bar system . The buss bar system has a 440 volt hot rail that could easily come in contact with the probe.

Another dangerous situation is best illustrated by this real incident that was related to me by an elevator manufacturer.

> *A stack tester took an 18-foot probe up in an elevator with the hatch open and the safety interlock bypassed. He failed to keep the probe vertical enough and it got caught on an I-beam at the first landing, 150 feet up. The probe twisted like a pretzel, trapping the technician inside*

and deforming the compartment. Fortunately, the thermal overload switch on the motor worked and shut down the elevator before the floor popped out. Unfortunately, the elevator car was so badly deformed that they couldn't move it or open it. The rescue team had to cut him out at 150 feet.. The cost to that testing company exceeded $50,000.00 for the repairs alone. I don't know what they had to pay for the rescue efforts.

At least one elevator manufacturer (Alimak) makes an attachment for their elevators for the purpose of carrying probes. Unless the elevator has a long probe carrying device, another means should be used for transporting the probes.

LADDERS

Permanently installed ladders are probably the most common means of access to the stack. Such ladders are usually installed with cages and/or other fall protection devices. There are several potential risks involved with the act of climbing a ladder; the most obvious, of course, is falling off. 100% fall protection while climbing a stack ladder is always advocated. 100% fall protection means that 100% of the time that the individual is exposed to a fall hazard he is protected and the fall risk is brought to virtually zero. This also means that a ladder safety device must be used. A ladder safety device incorporates a harness, friction brakes and/or sliding attachments. There are several types of ladder safety devices, some of which are listed below:

- Center toothed bar or rail with a trolley that attaches to your harness.
- Rope grabs that slide on a rope or a steel cable.
- Retractable lifelines.

A cage by itself does not provide 100% fall protection. Whenever redundant systems are present, both should be used.

Many safety devices require that you disconnect from the trolley prior to getting off the ladder. In those cases it is recommended that the climber must have a lanyard attached to the back "D" ring on his harness with the other end of the lanyard hooked to a front "D" ring in easy reach of the climber. Then you can disconnect the lanyard connected to the front "D" ring and reconnect it to an anchor point like a rung on the ladder prior to disconnecting from the ladder safety device. Now you can step off the ladder and still maintain continuous fall protection. **Make**

sure you close the gate or chain after you clear the entrance to the platform. Unguarded openings have been responsible for several severe accidents in our business.

Some other hazards to consider while climbing a ladder are falling objects from above or from you. To prevent injuries to you or others never carry anything in your hands. Keep them free for climbing. Always maintain 3 points of contact (2 feet and one hand, or 2 hands and 1 foot) when climbing ladders. Also, secure anything that you are carrying so that it cannot slip out and fall. Except in an emergency never allow more than one person on the ladder at one time. Wear your hard-hat and barricade the area below the stack.

It is important that you do not wear rings while climbing ladders. Some people have suffered severe finger injuries when they slipped and their ring got caught on a ladder rung. (In general, wearing of rings or other conductive or restrictive jewelry should be held to a minimum.)

Some ladders do not get used very often so it is also important to inspect a ladder before climbing to make sure they are safe and not corroded. It is not unusual to discover some wildlife on rarely used ladders. Wasps, spiders, bats and birds can offer some unwanted distractions. Leather gloves could offer some protection in this situation. Also, if the safety harness rail or center bar is warped, excessively dirty or corroded, you might need to take tools with you when you climb in case you get stuck. Remember to secure the tools so that they cannot fall.

Although climbing a ladder seems like a simple thing, personnel without prior experience should always be observed by an experienced supervisor at least the first time they climb a ladder to ensure proper climbing technique and use of safety equipment. There should not be more than one person climbing on the ladder at a time; wait until the ladder is clear before the second person begins climbing.

STAIRS

On occasion the access to the stack location is a stairway of some sort. Because people rarely think of stairs as being hazardous, they sometimes get complacent. Don't let this happen to you. There are hazards involved with climbing stairs and there isn't any back-up safety device to protect you if you make a mistake. The following are some safety tips regarding stairs:

- Always check the condition of the stairs before you climb. Stay off of stairs that are broken, deformed or corroded. Such conditions are not always detectable by visual inspection alone.

- Stairs must have handrails and should be kept clean and free of trip hazards. The handrails should be used when ascending or descending.
- Never run up or down stairs.
- If stairs get slippery from rain, snow, mud or ice they become extremely hazardous.
- Do not carry loads that are so big that you can't see the stairs you are about to use.
- Climbing stairs or ladders can be physically demanding. Take as many rest breaks as you need.

Ambient Temperature

Weather conditions often create additional hazards for source testers. Extreme cold, wind, rain, ice, the effects of the sun and excessive heat are all hazards that must be recognized and managed to prevent serious injuries. While most of these hazards only occur if you are working outside, excessive heat and extreme cold can happen at inside locations also.

MANAGING COLD STRESS

During cold weather about 60% of a person's body fuel is used to heat the body. When exposed to frigid temperatures, particularly for extended periods of time, a person will tire easily, and exposed skin will cool rapidly. This is prime breeding ground for the dangerous effects of the cold -- hypothermia and frostbite. Combine cold temperatures with water, including actual immersion, and trench foot becomes another potential serious ailment. Hypothermia and frostbite are very serious cold stress injuries that can be life threatening. Knowing how cold stress progresses can help a person understand how to prevent it.

The Cold Environment

An individual gains body heat from food and muscular activity and loses it through convection, conduction, radiation and sweating to maintain a constant body temperature. When body temperature drops even a few degrees below its normal temperature of 98.6ºF (37ºC), the blood vessels constrict, decreasing peripheral blood flow to reduce heat loss from the surface of the skin. Shivering generates heat by increasing the body's metabolic rate.

The following information was obtained from the website of the University of New Hampshire's Office of Environmental Health and Safety.

COLD CONDITIONS GUIDELINES FOR OUTSIDE WORKERS

Working in Cold Environments

Hypothermia, a lowering of the core body temperature to <95° F (<35° C) causes approximately 600 deaths each year in the United States according to the National Center for Health Statistics. Working in cold environments requires people to be aware of the risk of hypothermia and frostbite and understand how to protect the body from excessive exposure to cold conditions. The ambient temperature and duration of exposure to cold are keys to determining the level of risk from exposure. These guidelines should be used by UNH employees to reduce the risk of accidents and frostbite during outdoor work in cold weather.

How Cold is Too Cold?

Four factors contribute to cold stress: cold temperatures, high or cold wind, dampness and cold water. A cold environment forces the body to work harder to maintain its temperature. Cold air, water, and snow all draw heat from the body. Wind chill is the combination of air temperature and wind speed.

Wind Chill

The wind chill temperature is how cold people and animals feel when outside. Wind chill is based on the rate of heat loss from exposed skin caused by wind and cold. As the wind increases, it draws heat from the body, driving down skin temperature and eventually the internal body temperature. Therefore, the wind makes it FEEL much colder. For example, when the air temperature is 5°F, and the wind speed is 35 mph, your exposed skin receives conditions equivalent to the air temperature being -21° F, also known as wind chill temperature. At this wind chill temperature, exposed skin can freeze in 30 minutes.

In 2001, the National Weather Service (NWS) implemented the updated Wind Chill Temperature (WCT) index shown below.

Wind Chill Chart

Temperature (°F)

Wind (mph)	Calm	40	35	30	25	20	15	10	5	0	-5	-10	-15	-20	-25	-30	-35	-40	-45
5		36	31	25	19	13	7	1	-5	-11	-16	-22	-28	-34	-40	-46	-52	-57	-63
10		34	27	21	15	9	3	-4	-10	-16	-22	-28	-35	-41	-47	-53	-59	-66	-72
15		32	25	19	13	6	0	-7	-13	-19	-26	-32	-39	-45	-51	-58	-64	-71	-77
20		30	24	17	11	4	-2	-9	-15	-22	-29	-35	-42	-48	-55	-61	-68	-74	-81
25		29	23	16	9	3	-4	-11	-17	-24	-31	-37	-44	-51	-58	-64	-71	-78	-84
30		28	22	15	8	1	-5	-12	-19	-26	-33	-39	-46	-53	-60	-67	-73	-80	-87
35		28	21	14	7	0	-7	-14	-21	-27	-34	-41	-48	-55	-62	-69	-76	-82	-89
40		27	20	13	6	-1	-8	-15	-22	-29	-36	-43	-50	-57	-64	-71	-78	-84	-91
45		26	19	12	5	-2	-9	-16	-23	-30	-37	-44	-51	-58	-65	-72	-79	-86	-93
50		26	19	12	4	-3	-10	-17	-24	-31	-38	-45	-52	-60	-67	-74	-81	-88	-95
55		25	18	11	4	-3	-11	-18	-25	-32	-39	-46	-54	-61	-68	-75	-82	-89	-97
60		25	17	10	3	-4	-11	-19	-26	-33	-40	-48	-55	-62	-69	-76	-84	-91	-98

Frostbite Times 30 minutes 10 minutes 5 minutes

WIND CHILL (°F) = 35.74 + 0.6215T - 35.75($V^{0.16}$) + 0.4275T($V^{0.16}$)

Where T = Air Temperature (°F) V = Wind Speed (mph)

Effective 11/1/01

http://www.nws.noaa.gov/om/windchill/wind-chill

Preventing Cold Stress

Planning for work in cold weather is the key. Wearing appropriate clothing and being aware of how your body is reacting to the cold are important to preventing cold stress. Workers can face increased risks when they take certain medications, are in poor physical condition or suffer from illnesses such as diabetes, hypertension or cardiovascular disease.

Protective Clothing

Wearing the right clothing is the most important way to avoid cold stress. The type of fabric also makes a difference. Cotton loses its insulation value when it becomes wet. Wool, on the other hand, retains its insulation even when wet. The following are recommendations for working in cold environments.

- Wear at least three layers of clothing: 1) An outer layer to break the wind and allow some ventilation (like Gortex® or nylon), 2) A middle layer of down or wool to absorb sweat and provide insulation even when wet, and 3) An inner layer of cotton or synthetic weave to allow ventilation.
- Special attention should be given to protecting your feet, hands, head, and face. Your head should be covered (up to 40% of your body heat can be lost when your head is exposed). Fingers and hands lose their dexterity at temperatures below 59°F. Find gloves that will allow you to perform the tasks you need to perform and remember to put dry gloves on if your gloves get wet.
- Wear insulated boots or other footwear.
- Keep a change of dry clothing available in case work clothes become wet.
- Do not wear tight clothing. Loose clothing allows better ventilation.

Work Practices

- Drink plenty of liquids, avoiding caffeine and alcohol. It is easy to become dehydrated in cold weather.
- If possible, heavy work should be scheduled during the warmer parts of the day.
- Take short breaks in warm dry shelters out of the wind and cold.
- Try to work in pairs to keep an eye on each other and watch for signs of cold stress.

Engineering Controls

Some engineering controls that may be available to reduce the risk of cold stress.

- Radiant heaters may be used to warm workers.
- Shield work areas from drafts or wind.
- Use insulating material on equipment handles when temperatures drop below 30° F.

Supervisors and Managers

Supervisors and managers should watch for signs of cold stress and ensure that work schedules allow appropriate rest periods. Appropriate engineering controls, personal protective equipment and work practices should be used to reduce the risk of cold stress. Workers should be trained to:

- Recognize the environmental and workplace conditions that may be dangerous.
- Learn the signs and symptoms of cold-induced illnesses and injuries.

For more information on cold weather work, please contact the Office of Environmental Health and Safety at 862-4041. End of UH Information.

Harmful Effects of Cold

Trench Foot is caused by long, continuous exposure to a wet, cold environment, or actual immersion in water.

Symptoms: Symptoms include a tingling and/or itching sensation, burning, pain, and swelling, sometimes forming blisters in more extreme cases.

Treatment: Move individuals with trench foot to a warm, dry area, where the affected tissue can be treated with careful washing and drying, re-warming and slight elevation. Seek medical assistance as soon as possible.

Frostbite occurs when the skin tissue actually freezes, causing ice crystals to form between cells and draw water from them, which leads to cellular dehydration. Although this typically occurs at temperatures below 30ºF (-1ºC), wind chill effects can cause frostbite at above-freezing temperatures.

Symptoms: Initial effects of frostbite include uncomfortable sensations of coldness; tingling, stinging or aching feeling of the exposed area followed by numbness. Ears, fingers, toes, cheeks, and noses are primarily affected. Frostbitten areas appear white and cold to the touch. The appearance of frostbite varies depending on whether re-warming has occurred. The effects of frostbite are even worse if the tissues are thawed and then re-frozen.

Deeper frostbite involves freezing of deeper tissues (muscles, tendons, etc.) causing exposed areas to become numb, painless, and hard to the touch. Severe cases of frostbite can cause gangrene.

Treatment: If you suspect frostbite, you should seek medical assistance immediately. Any existing hypothermia should be treated first (See Hypothermia below). Frostbitten parts should be covered with dry, sterile gauze or soft, clean cloth bandages. Do not massage frostbitten tissue because this sometimes causes greater injury. Severe cases may require hospitalization and even amputation of affected tissue. Take measures to prevent further cold injury. If formal medical treatment will be delayed, consult with a licensed health care professional for training on re-warming techniques.

General Hypothermia occurs when body temperature falls to a level where normal muscular and/or cerebral functions are impaired. While hypothermia is generally associated with freezing temperatures, it may occur in any climate where a person's body temperature falls below normal. For instance, hypothermia is common among the elderly who live in cold houses.

Symptoms: The first symptoms of hypothermia, shivering, an inability to do complex motor functions, lethargy, and mild confusion, occur as the core body temperature decreases to around 95ºF (35ºC).

As body temperature continues to fall, hypothermia becomes more severe. The individual falls into a state of dazed consciousness and disorientation, failing to complete even simple motor functions. The victim's speech becomes slurred and his or her behavior may become irrational. They may also suffer from decreased visual acuity.

The most severe state of hypothermia occurs when body temperature falls below 90ºF (32ºC). As a result, the body moves into a state of hibernation, slowing the heart rate, blood flow, and breathing. Unconsciousness and full heart failure can occur in the severely hypothermic state.

Treatment: Treatment of hypothermia involves conserving the victim's remaining body heat and providing additional heat sources. Specific measures will vary depending upon the severity and setting (field or hospital). Handle hypothermic people very carefully because of the

increased irritability of the cold heart. Seek medical assistance for persons suspected of being moderately or severely hypothermic.

If the person is unresponsive and not shivering, assume he or she is suffering from severe hypothermia. Reduction of heat loss can be accomplished by various means: obtaining shelter, removal of wet clothing, adding layers of dry clothing, blankets, or using a pre-warmed sleeping bag.

For mildly hypothermic cases or those more severe cases where medical treatment will be significantly delayed, external-re-warming techniques may be applied. This includes body-to-body contact (e.g., placing the person in a pre-warmed sleeping bag with a person of normal body temperature), chemical heat packs, or insulated hot water bottles. Good areas to place these packs are the armpits, neck, chest, and groin. It is best to have the person lying down when applying external re-warming. You also may give mildly hypothermic people warm fluids orally, but avoid beverages containing alcohol or caffeine.

Safe Work Practices, such as changes in work schedules and practices, are necessary to combat the effects of exceedingly cold weather.

- Allow a period of adjustment to the cold before embarking on a full work schedule.
- Plan your activities well and anticipate and account for the possible effects the weather will have on the equipment so that you can avoid delays and reduce your exposure time.
- Always permit employees to set their own pace and take extra work breaks when needed.
- Reduce, as much as possible, the number of activities performed outdoors. When employees must brave the cold, select the warmest hours of the day and minimize activities that reduce circulation.
- Ensure that employees remain hydrated.
- Establish a buddy system for working outdoors.
- Educate employees to the symptoms of cold-related stresses --heavy shivering, uncomfortable coldness, severe fatigue, drowsiness, or euphoria.

- Notify your supervisor as soon as you experience or other members of the crew show signs of the cold stress symptoms.
- No one should work in areas exposed to –20˚ F even for a short time.
- In extreme cold conditions, ambient temperature and wind monitoring is recommended, with breaks at appropriate intervals for employees, to prevent excessive exposure depending on conditions.

The quiet symptoms of potentially deadly cold-related ailments often go undetected until the victim's health is endangered. Knowing the facts on cold exposure and following a few simple guidelines can ensure that this season is a safe and healthy one.

In using the Wind Chill Table, values of wind chill below -10˚ F are considered bitterly cold. Values of wind chill below -20˚ F are extremely cold -- human flesh will begin to freeze within one minute!

GENERAL PRECAUTIONS

The following are some additional steps that can be taken to minimize the risks:

- Monitor local weather forecast information daily and conduct cold stress assessments for all areas
- Provide adequate heated shelters for crew
- Maintain a suitable thermometer and anemometer (wind measuring device) at the site; these will be used to determine the equivalent chill temperature
- Charts for establishing acceptable working conditions based on temperature and wind speed made available
- Establish safe areas and paths, no wandering or sightseeing; this will help reduce the risk of getting lost

SLIPS AND FALLS

Winter is synonymous with icy and slippery surfaces. It is important to slow down and carry smaller loads when walking on slippery surfaces. The test leader must insure that the work areas are safe. Fall protection equipment will be necessary if slippery surfaces are present at elevated work areas. Sometimes it will be necessary for the test leader to postpone work if an area is too unsafe to walk on, such as a pitched roof.

WINTER DRIVING

When road conditions get bad its important to remember that the driver must make the call. Previous SES safety surveys have indicated that many source testing accidents happen during transit. Sometimes you may have to get off the road for a while or maybe even get a motel until the roads are safe again. Always bring a hat, gloves, and a warm coat on trips during the winter.

WORKING IN THE HEAT

(from the Alberta Human Resources and Employment "Workplace Health and Safety Bulletin)

The human body works at its best within a narrow temperature range. Move 2°C or more above or below the body's normal temperature of 37°C and problems can start to happen. 37°C is the body's core temperature, the temperature of the brain, heart and other organs. Skin temperature may differ from core temperature by a few degrees.

The body controls its core temperature in a few ways. Sweating lowers the temperature; shivering raises it. Increasing blood flow to the skin helps remove heat; reducing the flow of blood helps conserve heat. As a person works in a hot environment, their core temperature rises. To keep cool, the body sweats. The sweat then evaporates and cools the body. If the fluid lost as sweat is not replaced, the person becomes dehydrated and unable to sweat. The body then loses its ability to control its core temperature and serious heat problems can result.

The human body can adapt to hot conditions and work safely and comfortably. This is known as acclimatization. Depending on the person, acclimatization may take about four to seven days of working in hot conditions. Full heat adaptation takes up to three weeks of continued physical activity under hot conditions. Physically fit workers make this adjustment faster than unfit workers. Acclimatization is lost quickly — one week away from the hot conditions and a person loses their adaptation to the heat. A small percentage of people are unable to acclimatize at all.

Factors affecting how hot we feel

Six main factors affect how hot we feel:

(1) *Air temperature* – measured with a normal thermometer, this is the temperature of the air around us. Although it is the easiest factor to measure, it is the least important under hot conditions. If air temperature is the only measurement taken, it is difficult to predict how workers will be affected by the heat.

(2) *Humidity* – this is the amount of water in the air. Under hot conditions, people feel even hotter when the air is more humid than when it is drier. Although a person will sweat, the sweat will not evaporate as quickly if the air is filled with moisture. Less evaporation means less cooling.

(3) *Radiant heat* – this is heat given off by anything that is hot, such as the sun, molten metal, hot pipes, or a heater. It eventually heats the air, but heats people more quickly. Radiant heat affects any person working in sunlight or near a work process that radiates heat. By simply moving from sun to shade, a person can feel the difference that radiant heat makes.
(4) *Air speed* – also known as wind speed, moving air that is cooler than the skin cools a person.
(5) *Physical activity* – body temperature increases with physical activity. Under warm or hot conditions, physical activity can increase the effect of heat on a person.
(6) *Clothing* – clothing can shield a worker from radiant heat, prevent sweat from evaporating, or help to transfer heat. Protective clothing that is not appropriate under hot conditions can be a problem. This includes clothing that does not allow air or moisture to pass through it (air- or water-vapour- impermeable clothing), or multiple layers of clothing.

Other factors that may affect a person's ability to work in the heat include their age, health status, level of fitness, body weight, level of hydration, and their use of prescription and non-prescription drugs.

What is comfortable?

Our perception of temperature is very complex. Under ideal temperature conditions, persons are unaware of being too hot or too cold. This is when they feel "thermally comfortable" (see below).

Thermally comfortable	• feels ideal • neither too hot nor too cold
↓	
Thermally uncomfortable	• feels too hot or cold • uncomfortable but low risk of harm
↓	
Heat stress	• too hot • harm or serious harm can occur • this is a health concern

(This ends the information used from the Alberta bulletin)

CONTROLLING HEAT STRESS

Heat stress is a serious problem that can affect anyone that works in hot environments. It is not only dangerous to the individual's health, but possibly to co-workers as well because the victim may be unable to perform job duties in a safe manner.

According to the Occupational Safety and Health Administration (OSHA) the four environmental factors that affect the amount of stress a worker can tolerate in a hot work area are: (1) temperature, (2) humidity, (3) radiant heat (as from the sun or a furnace), and (4) air velocity. Personal characteristics such as age, weight, fitness, medical condition, and acclimatization also are extremely important to the level of stress an individual may feel.

HEAT-RELATED DISORDERS

OSHA outlines five different types of heat-related illnesses.

- **Heatstroke** is the most serious heat-stress illness because it can be fatal if not treated promptly. Heat stroke is caused by the body's failure to regulate its core temperature; perspiring stops and the body no longer is able to rid itself of excess heat. Signs of heat stroke include:

  - Mental confusion, delirium, loss of consciousness, convulsions, or coma;
  - A high body temperature sometimes as high as 106 degrees F;
  - Hot, dry skin that may be red, mottled, or bluish.
  - Fast, weak pulse and fast, shallow breathing.

Prompt first aid can prevent injury to the brain and other vital organs that may occur from heat stroke.

First Aid

1. Medical help must be summoned.
2. While waiting for help to arrive, move the victim to a cool area and don't leave the person alone.
3. Lay the victim on their back and if they are having seizures/fits remove any objects close to them so they won't strike against them. If the person is sick to their stomach, lay them on their side.

4. Cool the victim fast by removing any heavy and outer clothing or by soaking their clothing with cool water, and fan vigorously to increase cooling.
5. If the victim is conscious, offer cool water to drink, but don't let them drink too quickly. (About half a glass or 4 ounces every 15 minutes).
6. If ice is available, place ice packs under the armpits and groin area.

- **Heat exhaustion** results from fluid loss due to perspiring and affects workers who fail to drink enough fluids, take in enough salt, or both. Fluid loss causes blood flow to decrease in the vital organs, resulting in a form of shock. A worker with heat exhaustion still perspires but experiences extreme weakness or fatigue, giddiness, disorientation, nausea, or headache. The victim has clammy and moist skin, a pale or flushed complexion, and a body temperature that is normal or below normal.

First Aid

1. Move the victim to a cooler place and don't leave the person alone.
2. Place the victim on their back with feet up (about 6 to 8 inches).
3. Cool the victim by removing or loosening clothing, fanning, and applying cold packs.
4. Care for shock.
5. If the victim is conscious, offer cool water to drink, but don't let them drink too quickly. (About half a glass or 4 ounces every 15 minutes).
6. If the victim does not feel better in a few minutes, call for emergency help. ***Without prompt care heat exhaustion can quickly become heat stroke.***

- **Heat cramps** -painful muscle spasms- occurs when workers drink sufficient water but do not replace their bodies' salt or electrolyte loss. These muscular pains or spasms usually involve the abdominal muscles or legs. Cramps may occur during or after exertion and can be relieved by drinking salted fluids or fluids with electrolytes like *Gatorade.*

- **Fainting** may be a problem if the worker is unaclimatized. Victims usually recover after a brief period of lying down.

- **Heat rash** may occur in hot and humid environments where workers' skin surfaces are constantly bathed in perspiration. When extensive or complicated by infection, heat rash may impair a worker's performance or even result in

temporary total disability. Heat rash can be prevented by resting in a cool, dry place and allowing the skin to dry and by using talcum powder.

PREVENTIVE MEASURES

Most heat-related problems can be prevented so that the risk of developing heat-stress symptoms is reduced.

- **Drinking water** should always be available at the work site. The easiest way to prevent dehydration is to make sure you drink plenty of fluids. Fruit juices and sports drinks replenish minerals as well.

- **Avoid diuretics** like alcohol the night before or coffee because they increase the need to urinate, which causes fluids to leave your body when you need them the most.

- **Acclimatization** to heat through short exposures followed by longer periods of work in a hot environment can reduce some stress.

- **Engineering controls**, including general ventilation and spot cooling by fans at points of high heat production are helpful. Shielding is required as protection from radiant heat sources like the sun, hot duct work, or furnaces. Shelters that provide shade can be used as a shield from the sun, fire resistant treated plywood or other fire resistant insulating material can be used for shielding the radiant heat from duct work and furnaces. The use of power tools to reduce manual labor and the use of protective clothing are other ways to reduce the risk of heat exposure. If extremely hot conditions are expected, pack cooling vests and heat reflective clothing.

- **Scheduling** work to be performed at times other than the hottest time of the day is sometimes an alternative.

- **Clothing** made of lightweight cotton fabrics that allows perspiration to evaporate is advisable. Fire resistant materials are recommended.

- **Supervisors** must learn to detect early signs of heat stress in workers, and how to prevent conditions that lead to heat-related illnesses. Supervisors should also

consider the individual characteristics of workers when determining job assignments or if an individual should be monitored more extensively. Older workers, obese workers, and workers taking some types of medications are at greater risk for suffering heat stress disorders.

- **Educating employees** to be aware of the need to replace body fluids, salt, and electrolytes lost through perspiring and to recognize the signs of dehydration, exhaustion, fainting, heat cramps, and heat stroke is vital.

- The **"Buddy System"** should always be employed when working in hot environments.

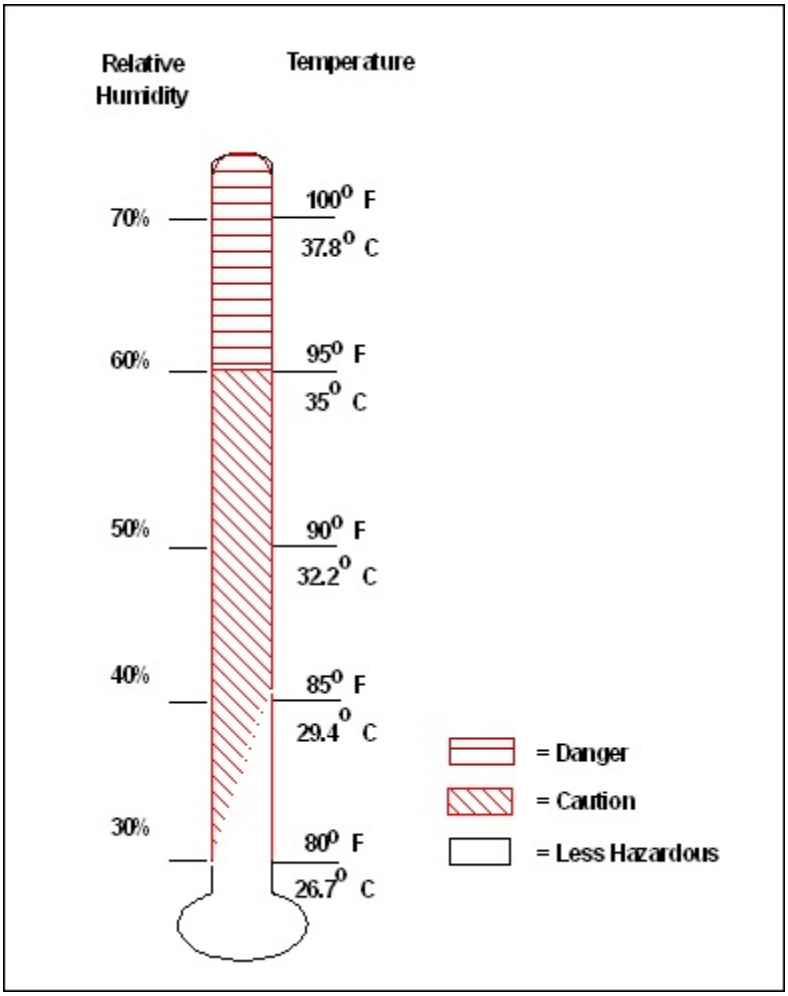
SALT

Although the National Safety Council and other occupational-health organizations currently recommend against the use of salt and salt tablets to prevent and treat heat stress, other organizations like OSHA still publish documents recommending the use of salt. Dr. Carl Gisolfi of the University of Iowa states that salt tablets don't always dissolve when they go into the system and in other cases people would take too many thinking that if one was good two or four would be better. In some cases high dosages actually lead to heat cramps. In other cases, the tablets interfered with a person's ability to use sweat to regulate body temperature because the salt retained water the body needed to sweat away. Most people consume around 5000 milligrams of salt a day, even though the human body only needs 200 milligrams daily to function properly.

THE HEAT EQUATION

HIGH TEMPERATURE + HIGH HUMIDITY + PHYSICAL WORK = HEAT ILLNESS

When the body is unable to cool itself through sweating, ***serious*** heat illnesses may occur. The most severe heat-inducted illnesses are ***heat exhaustion*** and ***heat stroke.*** If actions are not taken to treat heat exhaustion, the illness could progress to heat stroke and possible ***death***.



HEAT EXHAUSTION

What Happens to the Body:

HEADACHES, DIZZINESS/LIGHTHEADEDNESS, WEAKNESS, MOOD CHANGES *(*irritable or confused/can't think straight), FEELING SICK TO YOUR STOMACH, VOMITING/THROWING UP, DECREASED and DARK COLORED URINE, FAINTING/PASSING OUT, and PALE CLAMMY SKIN.

What Should Be Done:

- Move the person to a cool shaded area to rest. Don't leave the person alone. If the person is dizzy or light headed, lay them on their back and raise their legs about 6-8 inches. If the person is sick to their stomach, lay them on their side.
- Loosen and remove any heavy clothing.
- Have the person drink some cool water (a small cup every 15 minutes) if they are not feeling sick to their stomach.
- Try to cool the person by fanning them. Cool the skin with a cool spray mist of water or wet cloth.
- If the person does not feel better in a few minutes, call for emergency help (Ambulance or Call 911).

(If heat exhaustion is not treated, the illness may advance to heat stroke.)

HEAT STROKE - A MEDICAL EMERGENCY

What Happens to the Body:

DRY PALE SKIN (no sweating), HOT RED SKIN (looks like a sunburn), MOOD CHANGES (irritable, confused/not making any sense), SEIZURES/FITS, and COLLAPSE/PASSED OUT (will not respond).

What Should Be Done:

- Call for emergency help (Ambulance or Call 911).
- Move the person to a cool shaded area. Don't leave the person alone. Lay them on their back and if the person is having seizures/fits, remove any objects close to them so they won't strike against them. If the person is sick to their stomach, lay them on their side.
- Remove any heavy and outer clothing.
- Have the person drink some cool water (a small cup every 15 minutes) if they are alert enough to drink anything and not feeling sick to their stomach.
- Try to cool the person by fanning them. Cool the skin with a cool spray mist of water, wet cloth, or wet sheet.
- If ice is available, place ice packs under the arm pits and groin area.

How To Protect Workers

- Learn the signs and symptoms of heat-induced illnesses and what to do to help the worker.
- Train the work force about heat-induced illnesses.
- Perform the heaviest work in the coolest part of the day.
- Slowly build up tolerance to the heat and the work activity (usually takes up to 2 weeks).
- Use the buddy system (work in pairs).
- Drink plenty of cool water (one small cup every 15-20 minutes).
- Wear light, loose-fitting, breathable (like cotton) clothing.
- Take frequent short breaks in cool shaded areas (allow your body to cool down).
- Avoid eating large meals before working in hot environments.
- Avoid caffeine and alcoholic beverages (these beverages make the body lose water and increase the risk for heat illnesses).

Workers Are at Increased Risk When. . .

- They take certain medication (check with your doctor, nurse, or pharmacy and ask if any medicines you are taking affect you when working in hot environments).
- They have had a heat-induced illness in the past.
- They wear personal protective equipment (like respirators or suits).

OTHER WEATHER HAZARDS

Wind

Extreme wind conditions are hazardous and should cause the stack tester to evaluate the proper controls. Strong winds can often make it impossible to safely hoist equipment and sample trains up to a stack location. People should always wear fall protection equipment when strong winds exist. Monorails should be tired off to prevent swinging and, possibly, sample trains falling.

Blowing dirt and sand on windy days causes many of the eye injuries that occur. Eye protection is required to prevent those injuries.

Rain

Rain increases the chances for slips and falls. Non-skid boots and fall protection might be necessary.

Rain also increases the threat of electrical problems. Insulation for the probes can get wet and short out or cause someone to get shocked. Ground fault circuits tend to shut off your equipment causing frustration and delays. It is important to keep your equipment protected and dry with tarps or shelters. Extension cords should be of the proper gauge (should always be grounded with periodic ground wire checks) and circuits should not be overloaded. Always bring extra grounded extension cords and seal all connections.

Extra gloves should be made available so that testers can always wear dry non-conducting gloves. This can also prevent the possibility of burns from handling hot probes.

Sun Rays

Care should be taken to prevent sunburn while working outside. We know now that sunburn causes more than a temporary uncomfortable burn. The percentage of people who are getting skin cancer has been increasing at an amazing rate. Use at least SPF 15 sunscreen, cover up with lightweight clothes, wear UV protecting sunglasses and avoid exposure as much as possible. Set up tarps to create a shield for shade.

PERSONAL LIGHTNING SAFETY: THE SHORT VERSION

When you first see lightning or hear thunder, suspend activities and go to shelter. A metal vehicle or a substantial building is a safe place. Wait until 30 minutes after the last observed lightning or thunder before resuming activities (National Lightning Safety Institute, June 1998).

PERSONAL LIGHTNING SAFETY TIPS

1. ***PLAN*** in advance your evacuation and safety measures. When you first see lightning or hear thunder, activate your emergency plan. **STOP TESTING.** Now is the time to go to a building or a grounded vehicle. Lightning often precedes rain, so don't wait for the rain to begin before suspending activities.

2. ***IF OUTDOORS***...Avoid water. **Avoid the high ground**. Avoid open spaces. Avoid all metal objects including metal grating, stacks, electric wires, fences, machinery, motors, power tools, etc. Unsafe places include underneath canopies, small picnic or rain shelters, or near trees. Where possible, find shelter in a substantial building or in a fully enclosed metal vehicle such as a car, truck or a van with the windows completely shut. If lightning is striking nearby when you are outside, you should:

   A. Crouch down. Put feet together. Place hands over ears to minimize hearing damage from thunder.

   B. Avoid proximity (minimum of15 feet) to other people.

3. ***IF INDOORS***... Avoid water. Stay away from doors and windows. Do not use the telephone. Take off head sets. Turn off, unplug, and stay away from appliances, computers, power tools, & TV sets. Lightning may strike exterior electric and phone lines, inducing shocks to inside equipment.

4. ***SUSPEND ACTIVITIES*** for 30 minutes after the last observed lightning or thunder.

5. ***INJURED PERSONS*** do not carry an electrical charge and can be handled safely. Apply First Aid procedures to a lightning victim if you are qualified to do so. Call 911 or send for help immediately.

Annular Sampling Locations

This section deals with the performance of emissions testing at locations where access to sample ports is in an annulus, the area of a multiple walled stack structure situated between the outer walls of inner stacks and the inner wall of an outer stack. This type of location presents some unique conditions not found on conventional external platforms. Some of these conditions create additional challenges or concerns including:

Impaired Communication
Limited Exit Lighting
Potential Fall Hazards
Hazardous Atmospheres
Elevated Temperatures
Limited Hoisting Access

Each of the items listed above present a potential hazard to workers and warrant special precautions in order to provide for employee safety. The hazards and precautions are discussed below.

Note: This section is only concerned with those annular locations that are not considered to be a regulated or unregulated "Confined Space". OSHA (29 CFR 1910.146) defines confined space as a space that:

- *Is large enough and so configured that an employee can bodily enter and perform assigned work;*
- *Has limited or restricted means for entry or exit.; and*
- *Is not designed for continuous employee occupancy.*

The third criteria above excludes most annular stack testing locations from classification as a regulated confined space. However, the location may be considered an unregulated confined space. The information in this section will be

applicable only to those locations that are designed for continuous employee occupancy, having conventional OSHA approvable walking and working surfaces such as platform grating, hand rails, toe boards, protected ladder ways, etc. If an annular location is encountered in a testing situation that is not designed for continuous employee occupancy, it may fall under the definition of a regulated or unregulated confined space and require other precautions in addition to those suggested here.

IMPAIRED COMMUNICATION

Time is of the essence in any emergency situation. Communication between stack test personnel and support on the ground is an essential part of emergency response safety planning. Outside stack platforms provide for visual and often times direct voice contact between persons in transit to and on the platform and others on the ground. In contrast, the indoor annulus and associated ladders or elevators prevent direct visual or voice contact. Reliable means of communication are a must for these situations. Independent and redundant systems are recommended. This should include:

Battery operated two way radios and hard wired telephones or intercoms, or back up radios and back up batteries at both the platform and ground locations

LIMITED EXIT LIGHTING

Annular stack test location are essentially indoor locations that may not have windows to let in daylight. Most platforms will have installed electric lighting for general illumination. Emergency exit lighting is seldom provided. Test teams should be prepared to address this situation as part of preparing for a safe test. The following precautions should always be taken:

Battery operated flashlights should be provided at the platform location during the initial stages of setup, before the need for them arises.

POTENTIAL FALL HAZARDS

Some annular platforms are equipped with access doors on the outer stack walls to facilitate the insertion of long probes into the sample ports or mounting of monorails or to provide access to aircraft warning lights or other plant equipment. This access is often provided by hinged panels that swing inward onto the platform. When these panels are opened they can leave unguarded spaces that present potential fall hazards.

Protection from this hazard can be accomplished by:

Removing the hazard with temporary but adequate guard railing
Conventional fall prevention techniques and PPE such as lanyards
Fall protection PPE such as shock absorbing arrest systems.

HAZARDOUS ATMOSPHERES

The potential for contamination of breathing air exists in almost all stack test situations. This potential risk is increased when testing in annular spaces since these spaces are essentially indoors and any flue gas that enters the work area is less likely to become diluted with fresh air than in outdoor situations. Contamination of breathing air in annular test locations can occur from gas escaping from open sample ports or through the natural draft created when doors at the base of the stack are open or when forced draft annulus purge systems are in operation,. These drafts can collect flue gases escaping the process through leaks in duct work and introduce them to the breathing air supply for the test platform. The hazards that can be created include:

I. Elevated levels of air contaminants (SO_2, NO_x, CO, other pollutants)
II. Oxygen depletion
III. Increased dust loading

When testing from annular spaces the protection from these hazards includes:

Providing seals for sample ports to prevent the escape of flue gas into the work area.

Providing breathing protection for workers -

Acid gas filter respirators
Dust Masks
Fresh air supply as necessary

Providing additional forced air ventilation.
Keep doors and access panels below the sampling location closed.

ELEVATED TEMPERATURES

The lack of ventilation and close proximity to hot stack walls can raise the temperature at these locations above 100 degrees. Precautions against effects of exposure to heat include:

Increasing liquid intake
Wearing light clothing
Increasing the frequency of periodic rest breaks
Fans - preferably with outside air (cooler than ambient)

LIMITED HOISTING ACCESS

The ladders or elevators serving annular platforms may be constructed outside of the outer stack or be mounted inside the annulus. The locations where the access is via an outside ladder or elevator have similar access and egress provisions to the outdoor platform and do not involve additional hazards or precautions.

Locations with outside access generally provide for the hoisting of equipment using. At locations where access is only possible from inside the annulus through a ladder way or elevator the use of conventional over the handrail hand-over-hand or rope and pulley systems may not be possible. Long probes and oversized objects are especially challenging. Two common situations that can be approached safely are: 1) hoisting using the ladder way, or 2) hoisting using an elevator.

When hoisting equipment through a ladder way, do not allow personnel in that area to avoid possible injury from falling equipment.

Annular spaces served only by elevators do not have additional openings in the platform such as a ladder ways through which material can be hoisted. Testing equipment must arrive on the platform via the elevator. In this case the following precautions should be adopted:

Follow elevator instructions
Do not bypass safety controls
Do not ride outside elevator
Do not overload elevator

Testers may be tempted to place materials outside of the elevator for transport. This temptation can be very strong with regards to long sample probes or monorails. Many elevators are equipped with roof access panels that can be opened for maintenance or inspection purposes. In some cases these panels can be used to allow long material to be transported either by allowing the materials to extend out through the top of the elevator or by climbing through the panel and mounting the material onto the roof. On some elevators these panels are fitted with safety interlocks to prevent the elevator from operating while the panel is open. These interlocks must ***never*** be overridden under any circumstances.

If materials are to be transported outside of the elevator compartment the following guidelines should be followed:

Consult with plant operations and/or safety management before transporting materials
Do not override safety interlocks
Verify that adequate clearance exists in transport path (i.e. enough room above top landing for probes to prevent collision with roof). Perform test run from bottom to top before actually transporting materials
Fasten loads securely
Prevent or protect against falling during loading/unloading

Chemical Exposure

INTRODUCTION

Personal exposure to chemicals may involve materials in all three physical states: solid, liquid, and vapor. In the solid and liquid states the chemicals may be visible and provide some warning that potentially hazardous materials are present. Examples may be wetness, crystals, or buildup of material in a sampling port, near the outlet of a source, or on process surfaces. Chemical vapors and gases are usually invisible and may not offer adequate odor properties to warn of trouble. Inhalation is the predominant route of entry for chemical exposure.

The NIOSH/OSHA Occupational Health Guidelines for Chemical Hazards apply to worker exposures, including stack samplers. Plant exposure surveys are likely not to have included potential stack sampler exposures since sampling locations are frequently not visited by plant workers. For that reason, it may be necessary to make on-site measurements to ensure that NIOSH/OSHA guidelines are not exceeded. It is strongly recommended that the test team have available the NIOSH Pocket Guide to Chemical Hazards for reference.

GENERAL GUIDELINES

At your pre-test survey meeting with the source owner, identify what chemical materials are in each process stream. Ask the source representative what chemical exposures are most likely from each source. Many owners will have a safety program in place that you will have to follow. Review the in-house program and ask questions about any issues that are not clear to you. If the owner's representative does not know what the chemical composition of the process streams are, ask the representative to bring in someone who has additional knowledge that can answer your questions concerning potential chemical exposures. Don't forget that a nearby process you are not sampling may be emitting chemicals you could be exposed to. Ask if there are any batch processes nearby that may have short duration emissions that might affect the sampling team.

Survey the process location to be sampled and ask questions about anything that you feel may be a problem for you and your crew. Identify the nearest location of eye wash fountains and

safety showers. Ask for copies of the Material Safety Data Sheets (MSDS) for the materials you will most likely encounter. Read the MSDS before you arrive on- site, know what the hazardous properties of the materials are, and learn the symptoms of exposure. Understand the first aid and clean up recommendations before you arrive on site. Always try to pair people into buddy systems so there is someone available to assist if help is needed. Determine who your plant contact is for emergencies and how to initiate emergency medical services.

Monitoring

Exposure and biological monitoring should be employed in many situations. Personal monitors, such as radiation badges and portable gas monitors (nitrogen oxides, oxygen, carbon monoxide, sulfur dioxide, phosphine, and many other gases), are often available from the plant safety office if the test team does not have their own. Rental units are available from a number of companies specializing in industrial hygiene or HAZMAT monitoring equipment. These should be employed immediately upon commencing work if any exposures approaching NIOSH/OSHA guideline levels are suspected.

Swipe samples can be taken off of exposed surfaces where particular irritants or radioactive substances might result in exposures through ingestion or skin contact. Pull ambient work area air through a gas monitoring system to evaluate levels of carbon monoxide, nitrogen oxides, sulfur dioxide, and oxygen in stack sample areas in enclosed areas.

For companies conducting a significant amount of work in a particular industry where cumulative exposures might results, biological monitoring should be implemented. An example would be blood and urine analyses for heavy metals for individuals working frequently in the metals refining industry.

CHEMICAL EXPOSURE, ROUTES OF ENTRY, PREVENTION, AND FIRST AID

1. Ingestion

Wash hands prior to eating or smoking. Wearing protective gloves should minimize this route of entry. If chemical ingestion is suspected, contact the nearest poison control center for advice on emergency medical treatment. Obtain a MSDS on the ingested material and keep it with the patient.

2. Skin Contact

Many chemicals will absorb into the skin without any timely sensations or warnings. Wearing clothing that was previously contaminated is a problem here. Besides industrial chemicals, beware of urushiol (poison ivy oil) from vines growing on fences, poles or buildings which can remain on clothing for extended periods. Urushiols are removed by washing the clothes. A sensitive person can acquire a rash or allergic reaction by having contact with contaminated clothing worn by another person. Leather shoes contaminated with chemicals can become a reservoir for further skin contact. Chemically contaminated leather shoes are difficult to clean and should be thrown away.

Avoid contact with stained, wetted, or dirty surfaces on process equipment. Wear protective gloves and clothing if contact with chemicals is likely (see Personal Protective Equipment Guidelines for Stack Samplers). Be careful what you walk on or in; a harmless looking puddle may contain solvents or chemicals. Barrier creams are helpful to reduce skin absorption. Body areas that contact known or unidentified chemicals should be washed off with water as soon as possible followed by more thorough washing or showering with a bath soap.

3. Splashes to the Body, Face, and Eyes

Causes of splashes are generally from opening a full line or one that has some pressure in it. Be sure to open valves, plugs, flanges, etc. slowly ***after checking the operational status of the line***. Seek assistance from your plant representative if you have questions concerning the operational status of process equipment. After a splash exposure, wash off in an emergency shower and or an eye wash for at least 10 minutes. Follow the instructions on the MSDS for additional clean up and medical treatment especially if the employee exhibits symptoms listed on the MSDS. If an employee is unconscious, maintain an open airway and be prepared to

perform artificial respiration or cardio-pulmonary resuscitation (CPR) while waiting for emergency medical services.

4. Inhalation

As stated in the introduction, inhalation is the most common route for chemical exposure. Airborne chemicals can be present in the following physical/chemical forms: gases, vapors, dusts, fumes, and mists. Each form is defined below.

Gases: A material that does not condense at room temperature. Examples are carbon monoxide and nitrogen.

Vapors: Liquid or solid materials at room temperature that evaporate to the vapor phase, such as toluene vapor.

Dusts: Particulate matter that is airborne. In high concentrations the dust is visible. A strong light beam or sun light will cause the particles to sparkle (Tyndall effect).

***Fumes*:** Vapors usually generated by heat that condensed to form a very small airborne particulate. Examples are welding fumes or maleic anhydride fumes.

***Mists*:** Small airborne droplets of liquid that form a visible cloud in a light beam (Tyndall effect).

Since any airborne chemicals can be inhaled, it is very important to identify and have available for use the appropriate respiratory protection. Ask the source safety representative if representative exposure data area available for the location and operating conditions that will occur during testing. If not data area available and exposures exceeding the NIOSH/OSHA PEL area even vaguely possible, request that a survey be conducted or plan to conduct a survey for the test team. This can be accomplished using detector tubes, charcoal tubes, portable monitors, or other NIOSH/OSHA approved sampling techniques.

For airborne contaminants, air purifying or air supplying respirators that are suitable for the suspected materials and the concentrations must be available for the team members. See Protective Equipment Guidelines for Stack Samples for details of respirator selection.

If toxic or suffocating gases are present, use a full face respirator with supplied breathing air during events when samplers may be exposed. For airborne contaminants other than toxic or suffocating gases, air purifying or air supplying respirators may be used that are suitable for the material and the concentrations present. In most cases, using supplied breathing air systems will require special training and procedures to ensure uninterruptibility of the clean air supply. See Section 15, *Personal Protective Equipment,* for details of respirator selection.

Employees exposed to airborne toxic materials or suffocating gases should be removed from the area and be given first aid recommended in the MSDS. If an employee is unconscious, maintain an open airway and be prepared to perform artificial respiration or CPR while waiting for emergency medical services.

Cylinder Gas Safety

INTRODUCTION

The increasing number of requirements for the installation of continuous emissions monitoring systems and the increasing use of modern instrumental emissions test methods have led to the increased use of compressed gases. These gases are used for the purposes of calibration and quality assurance checks. Even though compressed gas cylinders are ruggedly constructed, compressed gas cylinders still must be handled with reasonable care. When any task is performed on a frequent or routine basis it is very easy for an individual to begin performing the task while consciously thinking of something else. It is at these times when accidents are most likely to occur. In other words, familiarity can breed carelessness. This is especially true when working with compressed gases where the packaging is so simple and innocuous in appearance.

This chapter is intended to offer some reasonable guidance regarding the storage, handling, transportation and use of compressed gases. The scope of this chapter is very broad in that it includes certain areas that most emission test teams will never have to deal with such as extinguishing fires and first aid measures. The broad scope of this chapter is intentional because it is intended to provide guidance that will be useful for both central locations (where cylinders are stored) and teams in the field; and, for very small companies (whose primary activity is testing) as well as very large companies (that conduct more diverse activities requiring storage and handling of a large number of cylinders). The reader is expected to make use of what is applicable and to discard those things that are not applicable.

This chapter refers to the need for a plan of action. This does not necessarily mean that the plan of action has to 500 pages long. In some organizations, the plan of action can be as simple as an agreement that, “If this happens, we run like hell.” In others, a more complex plan of action may be required.

The information in this chapter is by no means comprehensive and should not be used as the sole source for information concerning safety in working with compressed gas cylinders. Other sources of information concerning specific requirements include Occupational Safety and Health Administration (OSHA) regulations found in 29 CFR 1910 Subpart H, Subpart I, and Subpart Z; Department of Transportation (DOT) regulations found in 49 CFR Parts 171–179;

14 CFR Part 103; Compressed Gas Association Pamphlets C–6–1968, C–8–1962, P–1–1965, S–1.1–1963 with 1965 addenda, S–1.2–1963;National Fire Protection Association (NFPA) Codes, and information from the specialty gas suppliers. Other regulatory requirements may apply depending upon the specific gas being handled.

GENERAL CYLINDER GAS SAFETY

Cylinder gas safety is a matter of careful planning and training. First and foremost the user needs to identify the gases to be handled and make decisions concerning where and how the gases are to be used. Once these decisions have been made the user needs to become familiar with applicable federal, state, and local requirements. The user should then obtain Materials Safety Data Sheets (MSDS) for each of the gas mixtures to be used as well as any available supplier safety information in order to fully understand the properties and hazards associated with the materials being handled. Cylinder gas suppliers often have written materials and videotapes available; and, will offer specific safety training. It is recommended that users — no matter how experienced — take full advantage of these materials and opportunities. The user must not only understand the gas itself, but the container as well. A complete understanding of the container, the gas, and the gas handling system is essential to the safe use of compressed gases, and the development of any required emergency plans.

Compressed cylinder gases generally fall into one or more of the following seven categories. These categories are:

1. **Inert** — The primary hazard associated with inert gases such as carbon dioxide and nitrogen is asphyxiation. It is important to ensure that adequate ventilation is available in locations where these gases are handled, stored, and used so that the oxygen content does not drop below the minimum OSHA requirement of 19.5%.

2. **High Pressure** — The primary hazard associated with the handling storage, and use of high–pressure gases results from the sudden uncontrolled release of gas propelling a cylinder, whipping gas lines, and flying debris. The compressed gases used in emissions measurement and testing are stored at pressures as great as 2,000 psig or more. It is important to consider factors such as the potential effects of temperature, pressure, and pressure buildup in the selection of materials and the design of systems for the storage, transportation, handling, and use of compressed gases.

3. **Toxic** — The primary hazards associated with toxic gases are injury, illness, or death resulting from inhalation, ingestion, or absorption. The effects and the degree of toxicity vary for each chemical compound, as do the protective measures associated with each. For example, some compounds such as carbon monoxide provide no indication of their presence because there is no associated color, taste, or odor. Also, individually, innocuous chemical compounds may react or decompose to form toxic products. It is important to be familiar with the gases being handled and the potential for reaction; to ensure proper ventilation; and ensure that potentially exposed individuals have adequate training, protective clothing, and suitable breathing equipment in order to minimize exposure. Gases that are classified as toxic may also be classified as corrosive, oxidant, or flammable.

4. **Corrosive** — The primary hazards associated with corrosive gases include damage to human tissue in the form of deterioration or irritation (chemical burns), fabric, metals, and other materials. The damage may occur on a immediate or delayed basis. The effects may appear immediately or after prolonged exposure or after repeated exposures depending on the specific gas and the exposure level. Nitrogen dioxide and hydrogen sulfide are examples of corrosive gases. It is important to ensure that potentially exposed individuals have adequate protective clothing, equipment, and training necessary to minimize exposure. Gases that are classified as corrosive may also be classified as toxic, oxidant, or flammable.

5. **Oxidant** — The primary hazard associated with oxidant gases is fire or explosion resulting from the propensity for these gases to combine rapidly and sometimes explosively with other materials. In some cases, the toxic or corrosive properties of resulting products of oxidation or partial oxidation may be as much a hazard as fire or explosion. Oxidant gases are not in and of themselves flammable; however, in the presence of other materials these gases tend to support combustion. Care must be taken to ensure that oxidant cylinders do not come into contact with oil, grease, or other combustible materials. Preventive measures include storage of cylinders in separate area, training of personnel, and appropriate fire control measures. Gases that are classified as oxidant may also be classified as toxic or corrosive.

6. **Flammable** — The primary hazard associated with flammable materials is fire or explosion resulting from the ability of these gases to combine rapidly and sometimes explosively with other materials. In some cases, the toxic or corrosive properties of resulting products of oxidation or partial oxidation may be as much a hazard as fire or

explosion. The U. S. Department of Transportation defines as, "any compressed gas that either forms a flammable mixture with air at a concentration of less than 13% (by volume) or has a flammability range in air wider than 12 % regardless of the lower explosive limit (LEL)." Flammable gases are those gases that tend to burn or explode when mixed with an oxidant and exposed to an ignition source. Pyrophoric substances are those that self ignite when mixed with air or other oxidant containing mixtures at temperatures less than 130˚F. Two examples of pyrophoric substances are phosphine and arsine. The flammability limits for gases vary depending upon temperature, pressure, and oxidant concentration. The potential of fire or explosion can be reduced through the proper design of facilities and equipment, installation of approved electrical systems, elimination of ignition sources (e.g., smoking and open flames), the monitoring of concentrations (e.g., explosimeters), personnel training, and proper protective equipment. Gases that are classified as flammable may also be classified as toxic or corrosive.

7. **Cryogenic** — The primary hazards associated with cryogenic materials are tissue damage known as "cryogenic burns" resulting from the sudden evaporation of liquid. There is also a possibility of asphyxiation in the event of a large release because many of the cryogenic gases are inert and oxygen concentrations may be reduced below 19.5%. This category is included in the chapter for completeness even though cryogenic substances are not generally used in emissions testing and monitoring. Note: cryo-cooled detectors are being used in many Mobile Fourier Transform Infrared (FTIR) systems. One exception is "dry ice" which is solidified carbon dioxide. Due to the small quantities normally handled, the most generally applicable protective measures are the provision of training, protective clothing, adequate handling equipment, and ventilation. Depending on the quantities of materials handled additional measures may include the monitoring of oxygen concentrations.

   Table 1 lists some of the gases that are often used or encountered in emissions testing and monitoring and identifies the category to which each of the gases belong. Additional information can be obtained from compressed gas suppliers and the technical information published by these suppliers.

Anyone who is involved with the receiving, handling, or storing compressed gases should be required to wear eye protection in the form of safety glasses or a face shield, steel–toed boots or shoes, gloves, and a hard hat. Eye protection and foot protection should always be worn when working with compressed gases. When moving cylinders or opening and closing cylinder valves, appropriate gloves should be worn in order to protect the hands and fingers. Eye wash

media, first aid kits, fire extinguishers, and respiratory protection equipment (if appropriate) should always be available.

Table 1. Safety Categories

Gas	Oxidant	Inert	Corrosive	Flammable[1]	Toxic or Poisonous[2]
Ammonia	—	—	X	15–28	50
Argon	—	X	—	—	—
Butane	—	—	—	1.8–8.4	—
Carbon Dioxide	—	X	—	—	5000
Carbon Monoxide	—	—	—	12.5–74	50
Chlorine	X	—	X	—	1[3]
Ethane	—	—	—	3.0–12.5	—
Ethylene	—	—	—	3.1–32	—
Ethylene Oxide	—	—	—	3.6–100	1
Fluorine	X		X	—	0.1
Helium	—	X	—	—	—
Hydrogen	—	—	—	4.0–75	—
Hydrogen Chloride	—	—	X	—	5[3]
Hydrogen Fluoride	—	—	X	—	3
Hydrogen Sulfide	—	—	—	4.0–44.0	20[3]
Methane	—	—	—	5.0–15.0	—
Methyl Mercaptan	—	—	—	3.9–22.0	10[3]
Neon	—	X	—	—	—
Nitrogen	—	X	—	—	—
Nitric Oxide	X	—	X	—	25
Nitrogen Dioxide	X	—	X	—	3
Oxygen	X	—	—	—	—
Propane	—	—	—	2.1–9.5	1000
Sulfur Dioxide	—	—	X	—	2
Sulfur Hexafluoride	—	X	—	—	1000

[1] Flammability limits in air, % by volume
[2] OSHA 8-hr TWA, ppmv
[3] OSHA acceptable ceiling, ppmv

CYLINDER GASES

It is extremely important to have a prior knowledge and understanding of the properties, applications, and safety precautions for each gas that is to be used. For each gas, the user must obtain and study the Materials Safety Data Sheets (MSDS) and other safety information available from the supplier. A study of the available information and safety precautions can reduce the potential for injuries and damage resulting from asphyxiation, fire and explosion, chemical burns, chemical poisoning, cold burns, and high pressure.

There are potentially numerous hazards associated with the handling of compressed gases and these hazards vary with the gas being used, the equipment being used and the application. So, it is important that an experienced user or a supplier be contacted prior to attempting to perform an unfamiliar operation in order to become aware of the safe operating practices associated with each piece of equipment and to confirm compatibility.

RECEIPT OF COMPRESSED GAS CYLINDERS

Upon receipt each cylinder should be examined in order to verify that the order has been properly filled, establish a record of each cylinder for tracking and inventory purposes, and to determine that the cylinders are safe for use. The first thing to examine is the certificate that comes with the gas in order to make sure that the contents match the specifications of the order and that the gas is clearly within its certification period. The information stamped into the metal at the top of the cylinder should also be reviewed. One of the most prominent numbers to appear at the top of the cylinder is the DOT number, which has a form similar to "DOT 3AA XXXX." The first two alpha characters following the letters "DOT" identify the materials of construction such as "AL" for aluminum. The next four numerical digits indicate the service or working pressure for which the cylinder is rated. The serial number of the cylinder is also found at the top of the cylinder adjacent to the DOT number. The serial number is to be used to track the cylinder in inventory. The dates on which the cylinder has been hydrostatically tested for safety will also appear near the top of the cylinder and have the form "Month–Facility–Year–Plus Rating–Star Stamp." If a "+" sign appears in the "Plus Rating" position, the cylinder qualifies for a 10% overfill. If a "«" appears in the "Star Stamp" position, the cylinder meets the requirement for a 10–year retest. If a cylinder is received on a date that is substantially beyond the applicable retest interval, the cylinder gas supplier should be contacted prior to acceptance.

INSPECTION OF COMPRESSED GAS CYLINDERS

Compressed gas cylinders are pressure vessels and should be physically examined for signs of visible damage and checked for leakage upon receipt and after each use.

Cylinders should then be inspected in accordance with the following procedure.

Each individual cylinder should be visually inspected for any signs of surface damage such as cuts, gouges, burns, or obvious dents. Surface damage can weaken a cylinder and impair its ability to withstand the stress induced by the pressurized contents — ultimately leading to a catastrophic failure. Any visible signs of deformation can be an indication that the cylinder material is either defective or overly stressed and may be close to failure. Surface damage or deformation may be sufficient to make cylinder unstable and more likely to tip over. Each cylinder should be checked to make sure that it is steady when standing vertically on a level surface and does not wobble.

Each cylinder with neck threads must have a cap in place to protect the cylinder valve from damage. During the inspection, the cap is to be removed by hand to permit an inspection of the cylinder valve. If the cap cannot be removed with the hands, contact the supplier — do not try to forcibly remove the cap with a mechanical device as it may be hung on a damaged or bent valve. **Never use a screwdriver, crowbar, wrench handle, extension, or other leverage device to remove the cap because of the possibility of inadvertently opening or damaging the cylinder valve.**

Once the cap has been removed the cylinder valve should be inspected to make sure that it is not bent or damaged. Bent or damaged cylinder valves may be subject to leakage or failure and may not form a tight fit with the regulator or pigtail when the cylinder is placed in service. The cylinder valve should also be inspected to make sure that the valve is free of dirt and oil that could contaminate the gas. The presence of dirt, oil, or grease particles in the gas stream can cause damage to gas handling equipment and expensive instruments. Furthermore, dirt, oil, or grease particles can react with oxygen and other oxidizers to cause fire or an explosion resulting in physical injury.

If a cylinder is physically damaged or deformed; has bent, damaged, or dirty valve; a missing or damaged cap; missing label; or an unstable base — the damage should be marked, the supplier contacted for instructions; and the cylinder returned. The cylinder decal or label is the means of positively identifying the contents of a cylinder outside of a re-analysis. Never guess about the contents of a cylinder. If the contents are not actually known, then do not use the cylinder.

Each compressed gas cylinder should be checked for leakage if the cylinder cap can be removed with the hands — even those with signs of visible damage. One means of checking for leakage is to remove the cylinder cap and listen for the sound of leaking gas. Most leaks occur at the top of the valve in the top of the cylinder such as valve threads, pressure relief devices, valve stems, and valve outlet. Another means of checking for leaks is by spraying the area around the valve with a diluted soap solution. If the cylinder is found to be leaking, the cylinder valve should be checked to ensure that the valve is closed. If the cylinder continues to leak then the measures described in Appendix A the section on leaking cylinders should be implemented. **Do not attempt to repair leaks at the valve threads or safety devices.**

STORAGE OF COMPRESSED GAS CYLINDERS

> ***Note:*** *Whenever designing or selecting storage areas for cylinder gases, it is extremely important to consult local building codes, National Fire Protection Association (NFPA) codes and the rules of the state fire marshal.*

Compressed gas cylinders should be stored in a cool, dry area that is well ventilated and fire–resistant. The compressed gas cylinders must not be stored near any sources of heat or open flame such as radiators, furnaces, or other devices. Gas cylinders should never be subjected to temperatures of more than 125˚F. In addition, the compressed gas cylinders should not be stored in areas where electrical equipment, rotating equipment, vehicular traffic, or sparks (including those from welding or cutting torches) may be a hazard. The cylinders should never come into contact with electrical circuits or equipment. It is important that the selected storage area be one that can be sufficiently secured to prevent access by unauthorized individuals.

Outdoor storage areas must be protected from extreme climatic conditions. If the gas cylinders are stored in an outdoor area, the area should be covered and the cylinders should be elevated above the ground on a pallet or other well–drained surface. The cylinder gas storage area should be sufficiently screened from public view to prevent mischief by “would–be” weekend vandals.

Compressed gas cylinders must always be stored and secured in an upright position with the cylinder cap in place in order to prevent damage to the cylinders and the cylinder valves. The cylinders must either be secured to a wall or a permanent vertical support using cylinder gas brackets, cylinder gas clamps, or specially designed racks. The cylinders must be snugly

secured in the brackets, clamps, or racks by means of tie down straps or chains. Alternatively, cylinders may be stored together in groups of three or more providing they are tightly interlocked by straps to ensure that they are not easily tipped or subject to a domino effect if one is bumped.

It is extremely important to make sure that gas cylinders are stored in an organized manner. The empty cylinders should not be mingled with cylinders that contain a useable quantity of gas. A distance of at least 20 feet or a fire–resistant wall must separate cylinders containing oxidants from flammables and combustibles. Cylinders containing toxic gases should be separated from those containing oxidants and flammables. Each section of the gas storage area must be clearly identified in order to avoid the storage of incompatible gases in the same area. Smoking and open flames must be prohibited in the storage areas where oxidants or flammables are present and warning signs posted. The storage area should be kept free of oil, grease, and other combustible substances in order to reduce the risk of contamination, the risk of fire, and the potential for slippage whenever gas cylinders are being handled. Cylinders containing oxygen or other oxidant gases must never be permitted to come into contact with oil, grease, or other combustible substances. If cylinders are stored in an enclosed area, a portable multi–gas meter may be used to monitor concentrations to ensure adequate ventilation and avoid buildups of oxidants or flammables.

HANDLING OF COMPRESSED GAS CYLINDERS

When handling and working with compressed gas cylinders — it is extremely important to remember that each cylinder is a stressed pressure vessel containing a great deal of strain energy. These cylinders may appear rugged and innocuous; but improper handling or abuse can result in a violent release of that energy with accompanying damage and injuries.

Compressed gas cylinders should always be moved using a hand truck or specially designed gas cart. Never drop, slide, drag, or roll compressed gas cylinders. The cylinders must be protected from abnormal mechanical shocks (banging together, striking the ground, etc.) that might cause a failure of the cylinder valve, the safety device, or the cylinder itself. Each cylinder must be secured to the hand truck or cylinder gas cart by means of straps, nylon tie–downs, or chains. Upon reaching the new location, each cylinder must be secured to a wall, permanent vertical support, placed in a stand, secured to a workbench, or secured in a rack. Freestanding cylinders must not be left unattended and cylinders must be properly secured before being transported or placed in use.

The cylinder cap should always be in–place whenever a cylinder is being moved or handled. Cylinder caps must never be interchanged. The cap should never be removed until the cylinder is secured to a wall or permanent vertical support, placed in a stand, secured to a workbench, or secured in a rack. Never use the cylinder cap or the cylinder valve as a convenient handle when moving cylinders from one location to another. One of the end results can be a bent, broken, or unintentionally opened cylinder valve resulting in the unintentional creation of an unguided missile with attendant damage and injuries.

No one should ever attempt to catch a falling gas cylinder. There are two possible hazards associated with attempting to catch a falling cylinder. The first is a danger of missing and being injured by the falling cylinder. The second is catching the cap or valve and causing damage sufficient to either create a leak or an unguided missile. The best course of action is to shout a warning, get out of the way, and give the cylinder lots of room.

Elevators are often one of the most practical means of moving cylinders between elevations. It has been pointed out that elevators may become permit–required entry spaces pursuant to the OSHA regulations in 40 CFR 1910.146(b), when used to move cylinder gases from one elevation to another. It has been suggested that the issue of permit–required confined space entry may be avoided by properly securing the cylinder gases in the elevator; affixing a large, outward–facing “Do Not Enter” sign to the cylinders; and sending the cylinders to a designated individual at the destination level. Do not hand carry cylinders up or down stairs.

Cranes equipped with lifting magnets or slings ***must never*** be used for the purpose of moving compressed gas cylinders from one location to another. When it is necessary to use a crane for the purpose of transporting compressed gas cylinders, the crane must either be equipped with a platform cage or a sling.

Compressed gas cylinders must never be used as rollers for the purpose of moving other pieces of equipment.

TRANSPORT OF CYLINDER GASES

The rules of the Federal Department of Transportation and the appropriate state should be carefully reviewed prior to transporting cylinders containing compressed gas in order to ensure compliance. It is important to determine that the driver has the proper licensing and documentation, that the vehicle is properly marked, and that the cylinders are secured in accordance with any applicable regulations.

Compressed gas cylinders must always be secured in an upright position with the cylinder cap in place so as not to fall or bang together in order to prevent damage to the cylinders and the cylinder valves. The cylinders must be snugly secured in brackets, clamps, or racks by means of tie down straps or chains. The cylinder gas brackets, cylinder gas clamps, or racks must be properly secured to a permanent structural component of the vehicle and conform to any applicable federal or state requirements.

Gas cylinders should be reasonably protected from the elements and vandalism during transit. Compressed gas cylinders should never be subjected to temperatures of more than 125˚F. The cylinders should be relatively free of oil, grease, and road dirt in order to prevent contamination of the cylinder valves. It is also important that to ensure that the cylinders are secured in a manner that will prevent access by unauthorized individuals. Exposed or visible cylinders can present an attractive nuisance in some neighborhoods.

Check federal and state laws prior to transporting cylinders containing oxidants and cylinders containing flammables in the same vehicle at the same time. Even if the law permits, alternative solutions should be investigated.

If the cylinders are transported in an enclosed vehicle, it is important to first open the vehicle (van or trailer) in order to allow a little time for any accumulated gases to diffuse into the ambient air. While waiting for the vehicle to clear note any unusual odors or other items that may be indicative of a cylinder that is either leaking or has been damaged in transit. Depending on the gases being transported a small, portable multi–gas meter may be a good investment.

REGULATOR SELECTION AND USE

Regulators and pressure relief devices should always be used to connect compressed gas cylinders to systems or equipment with lower pressure ratings. It is important to ensure that the regulator, fittings, and other system components are constructed of materials that are compatible with the cylinder gas. Contact the cylinder gas supplier or consult tables published by the supplier in order to determine compatibility. The tables show the compatibility of materials such as stainless steel, brass, and Teflon® with specific gases. Table 2 is an example of how manufacturers typically present compatibility information.

Never use any regulator or other system component with any gases other than those for which it is intended.

The regulator is probably the most important feature of a compressed gas handling system because it must safely and reliably reduce the pressure of the gas to the working pressure of the system. The regulator is used to control delivery pressure only – the regulator is not a flow control device. Two basic types of regulators are used with toxic, corrosive, flammable, oxidant, or inert gases — single–stage and two–stage. There are numerous sub categories based on operational principles, internal design features, materials of construction, etc. It should be noted that the number of pressure gauges on a regulator do not provide an indication of the number of stages since both single–stage and two–stage regulators have two gauges. One gauge shows the cylinder pressure and the other gauge shows the delivery pressure.

Single–stage regulators reduce the pressure of the gas in the cylinder to the delivery or outlet pressure in a single step. In one type of single–stage regulator, the adjusting knob is turned clockwise in order to compress a spring that pushes against a diaphragm and the diaphragm pushes on a stem. The stem opens a valve that allows gas to expand into a chamber with the diaphragm until the total pressure of the gas against the diaphragm equals the pressure of the spring against the diaphragm. The gas pressure needed to establish this equilibrium condition is the delivery pressure of the system. In a single–stage regulator of this type (flow–to–close), the delivery pressure will increase as the pressure in the cylinder pressure decays because less pressure is exerted against the valve causing the valve to be opened to a greater degree. As a result single–stage regulators require more frequent adjustment in order to maintain a constant pressure and are suitable for use where exact control of delivery pressure is not required. Using a regulator of the flow–to–open type does not solve the problem of varying delivery pressure; instead the delivery pressure will drop as the cylinder pressure decays.

Two–stage regulators are basically two single–stage regulators in series. The first stage typically reduces the cylinder pressure to a fixed intermediate pressure of 350 – 500 psig. The second stage reduces the pressure from the intermediate value to the desired delivery pressure, which is set by adjusting the control knob. The outlet pressure from the first stage of the regulator tends to increase just as it does in a single stage regulator. However, the compressed gas flows into the second stage of the regulator where the effects of the decaying cylinder pressure are moderated so that the delivery pressure remains rather constant. As a result, two–stage regulators require less adjustment in order to maintain a constant delivery pressure and are well–suited to applications where precise control of delivery pressure is desired. It should be noted that two–stage regulators begin to function as single–stage regulators when the cylinder pressure drops below the set point of the intermediate stage. In applications where precise control of delivery pressure is desired, cylinders should be removed from service when the cylinder pressure reaches the set–of the intermediate stage.

Each regulator should be clearly identified and protected from damage and contamination when not in use. Regulators should never be lubricated and pipe dope should never be used in association with a regulator. Note: Inlet fittings are designed to be installed dry and must never be lubricated. Never exchange the pressure gauge on the low–pressure side of the regulator for a gauge with a lower pressure rating because the gauge can be ruptured if the adjusting unintentionally turned too far in the clockwise direction.

When putting a regulator into service, it is important to make certain that it is the appropriate regulator for the specific gas and pressures. This usually includes, but is not limited to, a check of the inlet gauge to make sure that is suitable for the cylinder pressure involved; the outlet gauge to make certain that it is suitable for the delivery pressures involved; and the fittings.

Prior to use, each regulator should be carefully inspected for evidence of physical damage, or wear. If there is evidence that a regulator is physically damaged or worn, it should be repaired, overhauled, or replaced. The manufacturer should be contacted concerning regulator overhauls and repairs. The operation of regulators to the point of failure is unsafe and does not really save any money. For oxidant regulators replacement is preferable to repair because the cleaning alone is usually more expensive that the price of a brand new regulator. In addition, there have been a number of improvements in the design of oxidant regulators and the associated materials that may substantially improve both safety and reliability.

CYLINDER VALVE INSPECTION

Before attaching the regulator, the cylinder valve should be inspected for evidence of physical damage or contamination. If there is any reason to suspect that a cylinder valve has been damaged or its integrity has been compromised, the cylinder must not be used and the supplier must be contacted. Users must never attempt the modification or maintenance of cylinder valves and must never attempt to tighten or loosen the cylinder valve assembly. In other words, users must not tamper with pressure relief devices, remove packing nuts on packed valves, adjust or tamper with retainer or bonnet nuts on diaphragm valves, lubricate valves or connection, or continue to use valves that become noisy or progressively harder to operate. Users must never use mechanical devices to open and close cylinder valves without the specific approval of the supplier. If a cylinder containing an oxidant has been contaminated with oil, grease, or other flammable substance, the cylinder is not to be used. In this case, the supplier is to be contacted. With regard to cylinders containing other substances, any foreign material should be removed prior to attaching the regulator.

Table 2. Material Compatibility Chart

Gas	Primary Hazards					Metals						Plastics						Elastomers				
	Asphyxiant	Toxic	Flammable	Corrosive	Oxidant	Aluminum	Brass	Copper	Monel	Stainless Steel	Carbon Steel	Kel-f	Teflon®	Tefzel	Kynar	PVC	Polycarbonate	Viton	Buna-N	Neoprene	Kalraz	Polyurethane
Ammonia		X	X	X		S	U	U	S	S	S	S	S	S	U	S	U	U	S	S	D	U
Argon	X					S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Butane	X		X			S	S	S	S	S	S	S	S	S	S	S	U	S	S	S	S	S
Carbon Dioxide		X				S	S	S	S	S	S	S	S	S	S	S	S	S	D	D	S	S
Carbon Monoxide		X				S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Chlorine		X				U	U	U	S	S	S	S	S	S	S	U	U	S	U	U	S	U
Ethane	X		X			S	S	S	S	S	S	S	S	S	S	S	—	S	S	S	S	S
Ethylene	X		X			S	S	S	S	S		S	S	S	S	—	—	S	S	S	S	—
Ethylene Oxide		X	X			D	D	U	—	S	S	S	S	—	—	U	U	U	U	U	D	U
Fluorine		X		X	X	D	D	D	S	S	—	D	D	D	D	—	—	U	U	U	—	—
Helium	X					S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Hydrogen	X		X			S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Hydrogen Chloride		X		X		U	U	U	S	S	S	S	S	S	S	S	U	S	U	U	S	U
Hydrogen Fluoride		X		X		U	U	U	S	S	S	S	S	S	S	S	—	S	U	U	—	—
Hydrogen Sulfide		X	X	X		S	S	—	S	S	S	S	S	S	S	S	S	U	S	S	S	S
Methane			X			S	S	S	S	S	S	S	S	S	S	S	—	S	S	S	S	S
Neon	X					S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Nitrogen	X					S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Nitric Oxide		X		X	X	S	U	S	S	S	S	S	S	S	—	S	—	—	—	S	S	—
Nitrogen Dioxide		X		X	X	S	U	U	U	S	S	S	S	—	—	U	—	U	U	U	S	U
Oxygen					X	U	S	S	S	D	D	S	S	S	S	S	S	D	U	U	D	S
Propane	X		X			S	S	S	S	S	S	S	S	S	S	S	U	S	S	S	S	S
Sulfur Dioxide		X		X		S	U	S	S	S	S	S	S	S	S	S	U	S	U	U	S	S
Sulfur Hexafluoride	X					S	S	S	S	S	S	S	S	S	S	S	—	S	S	S	D	S

S = Satisfactory for use with intended dry anhydrous gas @70°F
D = Suitability depends on conditions of use
U = Unsatisfactory for use with intended gas
— = Insufficient info about compatibility with intended gas

PLACING A CYLINDER IN SERVICE

Upon completing an inspection of the cylinder valves the gas handling system should be carefully inspected to ensure that all valves (including check valves} and other appropriate hardware are in place, have been properly installed, and are properly positioned. Gas handling systems should always be equipped with appropriate back flow protection. Never reverse flow through a regulator or depend upon it for back–flow protection — regulators will not provide back–flow protection.

It is important to make sure that the regulator is attached to the cylinder and the inlet nut thoroughly tightened. The regulator should then be carefully connected to the gas handling system. Extra attention is required in the use of brass regulators in order to avoid damage and leaks due to inadvertent cross–threading or over–tightening of the connections. This is one reason that stainless steel or Monel metal should be chosen over brass whenever the option is available.

Once the regulators have been connected to the cylinders and the gas handling system — close the regulator by turning the adjusting knob (the large knob) to the full **counterclockwise** position. The regulator **must** be closed prior to opening the cylinder valve.

Note: Many regulator outlets are equipped with a needle valve to control flow. If so equipped, the flow control valve must be closed prior to opening the cylinder valve. The flow control valve is adjusted by turning the small knob on the regulator outlet clockwise (rotation is opposite the regulator adjusting knob) to the fully closed position.

When opening the cylinder valve do not stand in front of the regulator outlet and do not stand in front of the gauges. Stand with the cylinder valve between you and inlet side of the regulator. Place both hands on the cylinder valve and slowly cylinder valve allowing the pressure to rise slowly until the inlet gauge reads the maximum pressure of the cylinder. The hand wheel on most cylinder valves of the diaphragm type will travel about 1¼ turns from full closed to full open. When opening the valve resistance will be felt for the first full turn. If the valve stem is not mechanically linked to the diaphragm resistance will seem to disappear and the hand wheel will turn freely. At this point the stem has contact with the diaphragm and the valve is full open as indicated by the inlet pressure gauge. If the valve stem is mechanically linked to the valve stem, the hand wheel will not spin freely; however, it will be full open after about the first full turn as indicated by the inlet pressure gauge. This is an appropriate time to check diaphragm type regulators for evidence of a condition known as creep which is leakage from the high–pressure

side to the low–pressure side of the regulator. In order to avoid confusion concerning the status of a cylinder valve, the valve should never be back–seated (back–stopped).
Note: In those cases where a pigtail is used to connect the regulator to the cylinder, it is still important to stand in the position described when opening the cylinder valve because the pigtail is a high–pressure line that can rupture and whip–around upon initial pressurization resulting in injuries.

Once the cylinder valve has been opened the regulator should be adjusted to the appropriate outlet pressure using the large adjustment knob (then if present the regulator outlet flow control valve opened), and the system checked for leaks by listening for the sound of leaking gas and spraying connections with a weak soap solution. If leaks are noted, the system must be shutdown by first turning the large adjustment knob on the regulator to the full counterclockwise position, closing the cylinder valve in accordance with the following section, and relieving the pressure through an appropriate vent by turning the large adjustment knob on the regulator to the clockwise position. Make sure both the inlet and the outlet pressure gauges drop to zero. Once the pressure has been relieved, the large adjustment knob on the regulator must be returned to the full counterclockwise position and the regulator outlet valve closed (by turning the small knob in the clockwise direction) in order to protect both the regulator and the system. Once the leaks have been repaired the system should be pressurized and rechecked. If there are no leaks proceed to use the cylinder gas. Cylinder valves are not regulators and must never be used to adjust or control flow or pressure. If the system is intended to handle oxygen make certain that only oxygen compatible components such as Teflon® are used to address leaks.

Whenever, cylinders are not going to be used for an extended period of time the cylinder valves should be closed and that portion of the system depressurized in accordance with the following section.

REMOVING A CYLINDER FROM SERVICE

In order to remove a regulator from service, close the regulator by turning the large adjustment knob on the regulator to the full counterclockwise position and the small adjustment knob on the flow control valve to the full clockwise position. This must be done regardless of the amount of pressure indicated by the inlet and outlet gauges in order to ensure safety. Once the regulator and the flow control valve have been completely closed, close the cylinder valve by using both hands to slowly turn the cylinder valve in the clockwise direction. Once the cylinder valve has been closed, the regulator should be opened by turning the large adjustment knob in the

clockwise direction and the small adjustment knob on the flow control valve in the counterclockwise direction in order to relieve the pressure from both the regulator and the system. Do not attempt to disconnect the gas handling system and do not attempt to remove the regulator from the cylinder unless both the inlet and the outlet pressure gauges drop to zero after the pressure is relieved. If the gauges do not drop to zero, close the regulator valve by turning the large adjusting knob in the counterclockwise direction and start checking the system by making sure the cylinder valve is closed. If the cylinder valve is fully closed, partially open the cylinder valve and close it again to reseat the valve. Then proceed to open the regulator by turning the large adjusting knob in the clockwise direction and the flow control valve by turning the small adjusting knob in the counterclockwise direction. If both the inlet and outlet pressure gauges do not drop to zero continue checking the system to see if a check valve has been tripped or a vent blocked. **Never attempt to remove a regulator from a cylinder until both pressure gauges indicate zero no matter how many attempts are required to obtain a zero reading on both gauges.**

It is important to note that it is easier to open cylinder valves than it is to close them — especially diaphragm type cylinder valves. Cylinder valves of the diaphragm type are usually difficult to close because the stem on the hand wheel must push a diaphragm with an area of about one square inch down against the full pressure of the cylinder gas which can have a pressure of as much as ~2,000 psig. Less than half of the force of closure is transmitted to the valve seat while more than half of the force is actually used to depress the diaphragm. As a result many diaphragm valves are either barely closed or slightly leaking. This problem may be overcome by opening the regulator and venting the system once the cylinder valve is closed, then closing the regulator, slightly opening the cylinder valve, and closing it again to reseat the valve. Care should be exercised to avoid over tightening cylinder valves, because over tightening can deform the valve seat and result in gas leakage.

EMPTY CYLINDERS

Cylinder gases should never be completely drained of pressure. Suppliers prefer that cylinders be shipped with at least 25 psig. This is not a problem for specialty gases since the certificates for protocol gases usually indicate that the analysis is valid to 150 psig. Once the cylinder is considered empty, the regulator must be removed, the protective cylinder valve caps replace, the cylinder cap attached, and the cylinder labeled as empty. Care should be taken to avoid damaging, defacing, or obscuring the label showing the original contents. The cylinder should then be properly stored in a designated area until ready for shipment to or pickup by the supplier.

If a cylinder becomes contaminated as a result of back flow the cylinder must be removed from service and the supplier contacted immediately.

Compressed gas cylinders must never be refilled without the consent of the owner. The shipment of compressed gas cylinders that have been refilled without the consent of the owner and by someone other than the owner is a violation of federal law. Empty gas cylinders should never be used for anything other than the originally intended purpose because of the potential for violent reactions, the formation of toxic substances, etc.

SAFE COMPRESSED GAS CYLINDER RULES

1. Wear safety glasses with a side shield when working with or around cylinders.
2. Wear gloves when working with compressed gas cylinders
3. Always secure the protective valve cap on cylinders when idle or in transportation.
4. Always keep a fire extinguisher available where compressed gases are stored.
5. Segregate your full from empty cylinders.
6. Know the contents of your cylinders before using them (MSDS, Certifications).
7. Always perform a leak check of your equipment to look for possible leaks.
8. Never store cylinders in areas that can exceed 125degrees F, or where they can come in contact with object at extreme temperatures like furnaces, space heaters, cryogenic liquids
9. Never store cylinders where they can come in contact with corrosive materials.
10. Never store cylinders where they can come part of an electric circuit store away from electrical switches, outlets and extension cords.
11. Never store cylinders where water is free standing or may collect.
12. Never store cylinders containing a flammable or oxygen gas near any ignition source.
12. Never attempt to modify any valve components on a cylinder or gas apparatus.
14. Never use cylinders as supports, door stops, or other non gas delivery use.
15. Never lift a cylinder by the protective valve cap or the valve.
16. Never move cylinders by rolling them on their side.
17. Never alter or cover cylinder labeling or marking
18. Never lubricate or use pipe dope on cylinders or fittings, keep all cylinder fittings clean and free of dirt and grease.
19. Never transport cylinders in confined areas in vehicles such as passenger compartments, or trunks of cars.
20. Never attempt to open a cylinder where the valve is stuck shut beyond the use of a specific cylinder wrench for the job.

LEAKING CYLINDERS OF COMPRESSED GAS

Minimal Leaks

When leaks are minimal and action can be taken without serious exposure to hazards, the leaking cylinder should be quickly moved to an isolated area that is isolated and well–ventilated. Warning signs describing the hazard should be posted and the cylinder gas supplier immediately notified. For gases that are classified as flammable, inert, or combustible, it is important to ensure that the isolated location is sufficiently ventilated to dissipate gas concentrations. If the leaking gas is either flammable or an oxidizer the selected isolation area should be away from any combustible material. For gases that are classified as corrosive or toxic, a suitable means should be used to direct the discharging gas into an appropriate chemical neutralizer following transfer of the leaking cylinder to an area that is isolated and well–ventilated. If the gas is classified as corrosive, the size of the leak may actually increase in size. It is important to remember that some of the gases classified as corrosive are also classified as oxidants or flammables and would require implementation of additional measures (e.g., isolation from combustible material).

Large or Uncontrollable Leaks and Releases

Large or uncontrollable leaks and releases of compressed gases should be handled in accordance with an emergency action plan developed from Material Safety Data Sheets (MSDS), cylinder gas supplier safety information, National Fire Protection Association (NFPA) guidelines, etc. Even a two-person test team needs a plan of action. Some of the appropriate measures include:

- The immediate evacuation of personnel.
- The rescue of injured personnel by individuals with adequate protective clothing and breathing apparatus. There are too many instances where “would–be” rescuers become casualties because they were inappropriately equipped. Depending on the gases involved, the extent of the injuries, and the MSDS data, it may be appropriate to contact local EMT services.
- Initiate appropriate fire prevention/fire fighting procedures. Depending on the scale of the incident and the risks involved, the appropriate actions may include contacting the local fire department.
- Decontaminate the affected area, if necessary.
- Perform emergency repairs.
- Contact the cylinder gas supplier.

Appendix B on first aid measures for inhalation and Appendix C on procedures for extinguishing fires include general information that is intended to be of assistance. However, the information in

those sections of this chapter is by no means comprehensive and is not intended to be. It is extremely important that those handling specific compressed gases obtain as much information concerning specific first aid and fire procedures as possible for those gases.

Acknowledgments

The Source Evaluation Society and Harley Engineering and Technologies (HEAT) wish to thank Bubba O'Steen of Air Products and Chemicals, Bob Davis of Airgas, and the nice folks in Praxair's Orlando Office for providing much of the information that made this Chapter possible.

See Appendices for more information.

DAVIT CONSTRUCTION AND USE

Webster's Contemporary American English Dictionary 2003 Edition defines "davit" as "a small crane on a ship used in pairs, esp. to raise and lower boats." Davits also are used in the maintenance of the exteriors of tall buildings. The davits discussed in this chapter are not the kind found on ships, nor are they the kind used to raise and lower painters and window washers; they are the kind a stack tester would use to hoist equipment up to a testing location.

ENGINEERING ANALYSIS

To build a davit one must start with an engineering analysis where the maximum loads on each component are estimated. The calculated loads are then used to select properly sized components, such as bolts, pins, cables, rope, pulleys, etc.

Figure 1 illustrates a simple davit being used by a stack tester. The davit is an I-beam that has been pinned to a support on the stack wall; pinning in this manner is a common method of reducing lateral loads and wind loads. At the other end of the davit there is a pulley with a continuous piece of rope which supports a bucket of stack testing equipment being hoisted to the platform by a worker on the ground. Figure 1a is a free body diagram of the same davit with some of the important dimensions and forces labeled. W_B is the weight of the beam and it acts at a distance d_1 from the restrained end of the beam. L is the load and it equals the sum of the weight of the pulley, W_P; the weight of the rope, W_R; the weight of the bucket of equipment, W_E; and the force the worker is applying to the rope, F. If the worker is raising the bucket at a constant rate, then the force he/she is exerting is equal to the weight of the bucket of equipment. L is acting at a distance of d_2 from the restrained end of the I-beam. So we have:

$$L = W_P + W_R + W_E + F$$

or

$$L = W_P + W_R + 2W_E$$

In Figure 1a, S is the shear force being applied to the beam by the stack to restrain the beam, and it is the sum of the vertical forces acting on the beam, that is:

$S = W_B + L$

The connection to the stack also restrains the beam by applying a bending moment, M. A moment is force times lever arm so M can be written as:

$M = W_B d_1 + L d_2$

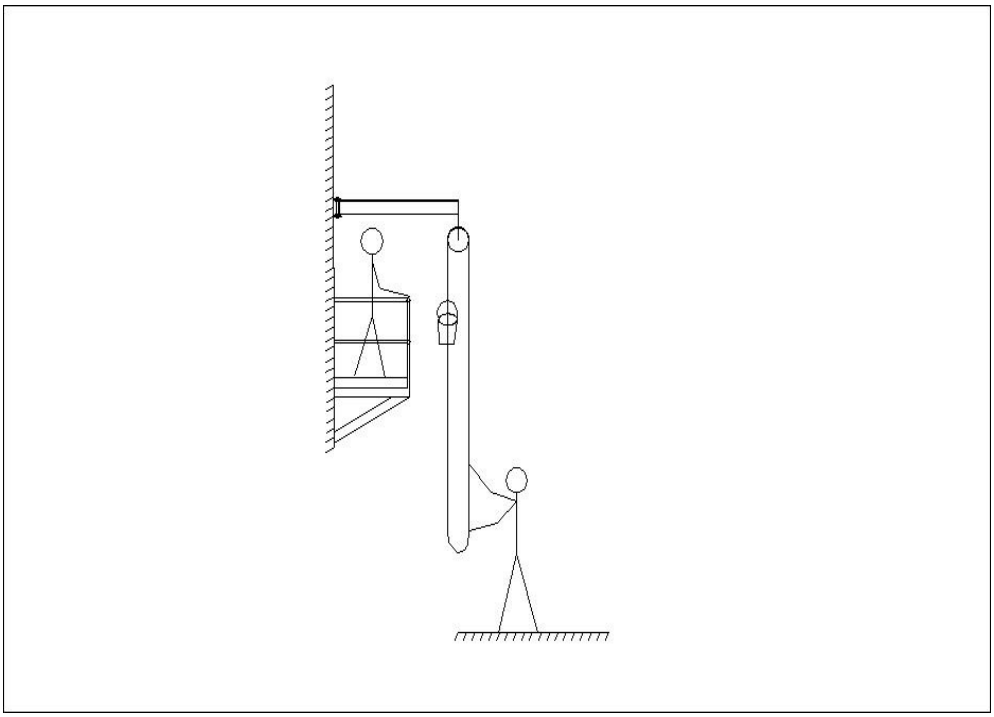


Figure 1. A simple davit being used by a worker to raise a bucket of equipment.

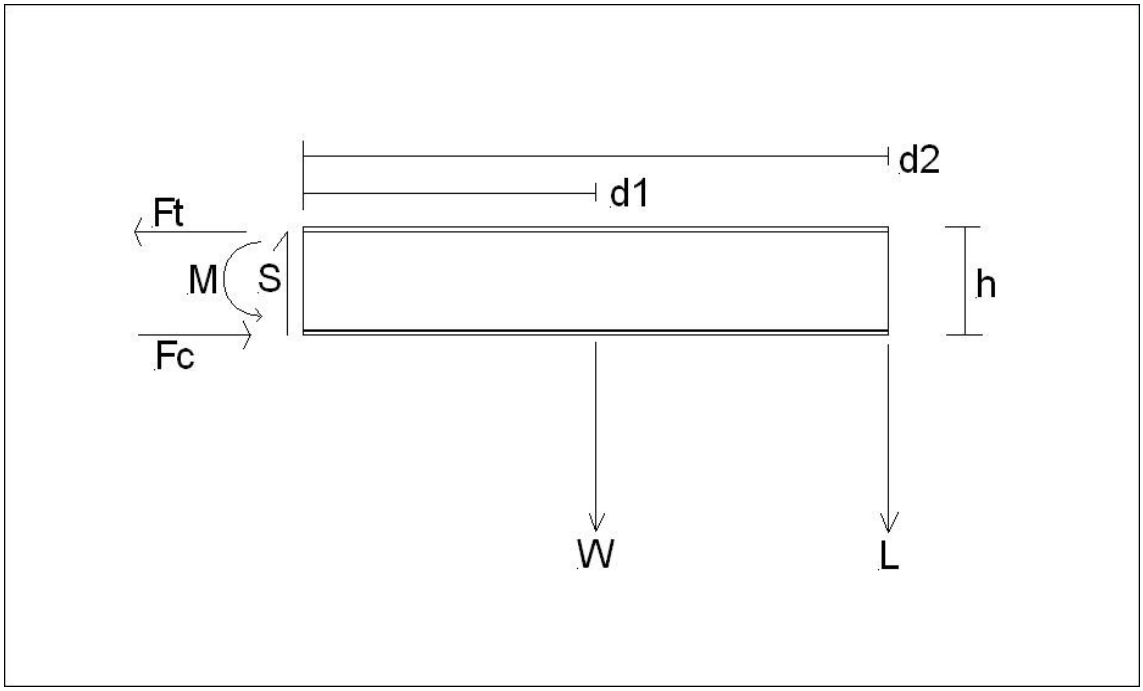


Figure 1a A free body diagram of figure 1.

This moment causes the top of the beam to be under tension and the bottom of the beam to be in compression. The tensile force F_T will be equal to the compressive force F_C such that:

$F_T = F_C = M / h$

The beam must be able to transmit these loads with a factor of safety to prevent failure. In addition the tensile and compressive forces will act as sheer forces on the pin or bolt that the davit swings on, and the stack itself must be able to withstand the additional loads placed on it.

The illustration above is one of the most simple designs of a davit possible, and because of the simplicity, the engineering analysis is not too complicated. The analysis is called a "static" analysis because it is assumed that all of the components are rigid, that is they do not move or deform. If you did not follow the math above, or if you have never seen such an analysis, you should not attempt to design your own davit. Find an engineer at the plant where you need the davit and get some help.

To show how a small load can lead to large internal forces let's put some reasonable numbers into the equations above; let's assume that we have a 10 foot long steel beam that is 6 inches high and weighs 100 lbs and that our load, L, is 50 lbs. This leads to the following:

$$W_B = 100 \text{ lbs}$$
$$d_1 = 5 \text{ ft}$$
$$L = 50 \text{ lbs}$$
$$d_2 = 10 \text{ ft}$$
$$h = 0.5 \text{ ft}$$

$$M = (100 \text{ lbs})(5 \text{ ft}) + (50 \text{ lbs})(10 \text{ ft})$$
$$= 500 \text{ ftlbs} + 500 \text{ ftlbs}$$
$$M = 1000 \text{ ftlbs}$$

$$F_T = 1000 \text{ ftlbs} / 0.5 \text{ ft}$$

$$F_T = 2000 \text{ lbs}$$

This means that the 150 lbs that we started with results in 2000 lb internal forces at two (or more) points in the davit, and illustrates why the engineering analysis is so important. This also shows that the example above may not be the optimum design and that some modification may be necessary.

A modification to reduce the internal forces in the davit is shown in Figure 2; here a cable has been added which runs from the stack wall above the beam to the end of the beam supporting the pulley. Figure 2a shows a free body diagram and the static analysis for this structure. Unfortunately, the number of unknown forces and moments is greater than the number of equations, so the static analysis is insolvable. This is called a "statically indeterminate structure."

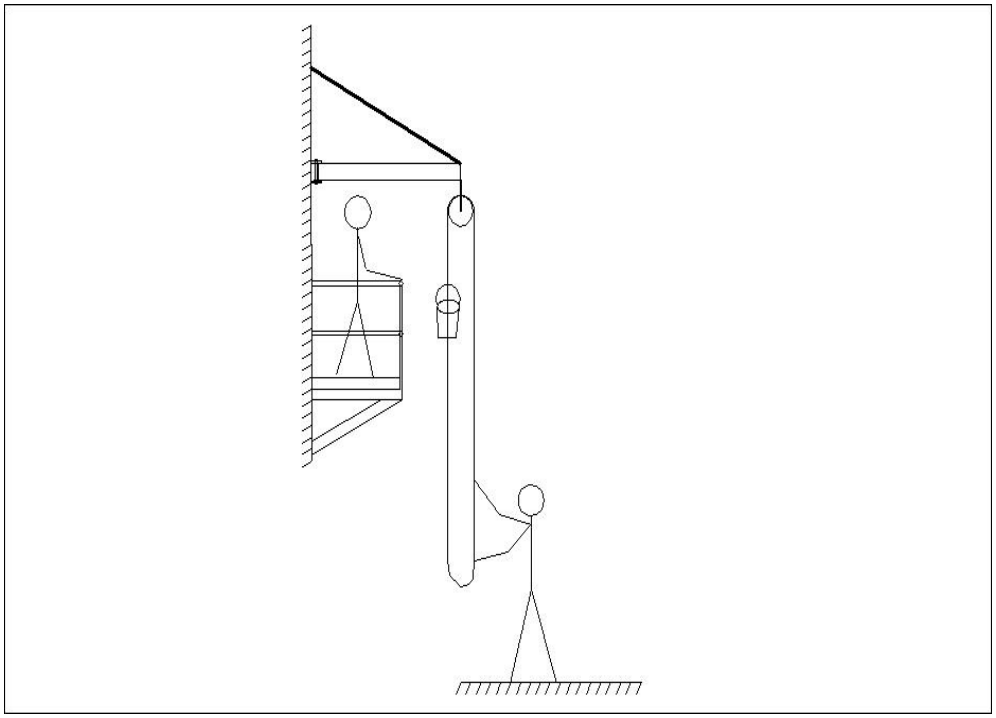
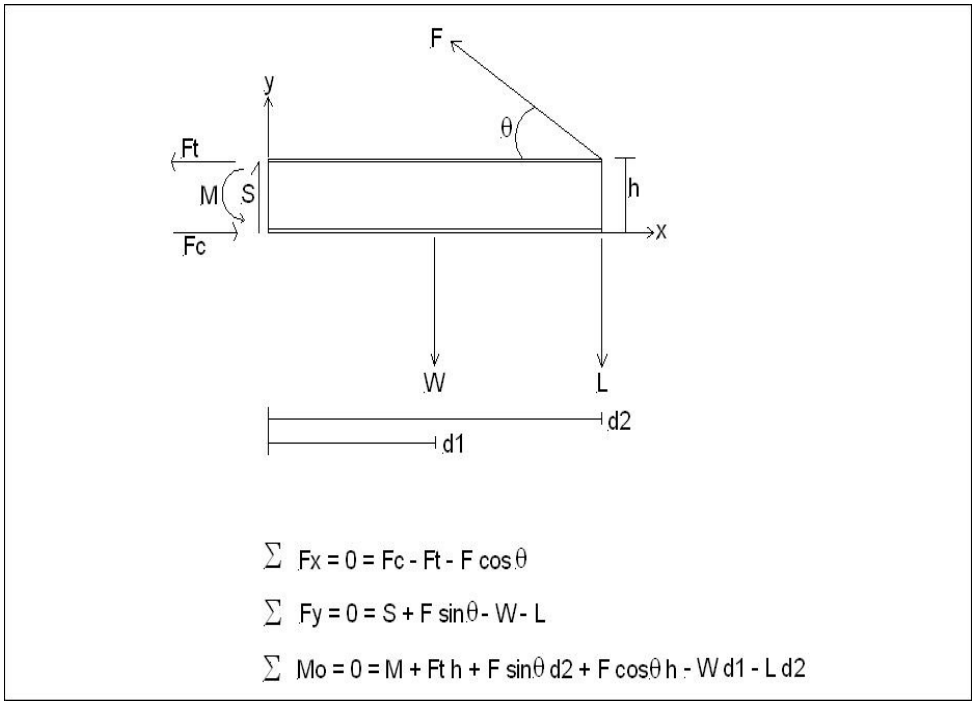


Figure 2 The davit from Figure 1 modified with a cable to support the end of the beam.



$\sum Fx = 0 = Fc - Ft - F\cos\theta$

$\sum Fy = 0 = S + F\sin\theta - W - L$

$\sum Mo = 0 = M + Ft\,h + F\sin\theta\,d2 + F\cos\theta\,h - W\,d1 - L\,d2$

Figure 2a. Free Body Diagram of Figure 2.

To analyze a statically indeterminate structure, a "mechanics of materials" analysis must be undertaken. The mechanics of materials analysis is fairly complicated and well beyond the scope of this chapter, but basically the components are allowed to deform, i.e., in reality the beam will bend and the cable will stretch. By knowing how much each component will deform under a given load - the mechanical properties of the materials- more equations are added to the problem allowing it to be solved.

The **design and engineering analysis** is arguably the **most important aspect** of davit construction. It **must always be done** because failure could result in serious injury, death, or property damage. Because the analysis is not trivial, **a competent engineer** should do it with input from those who will be using it.

PLACEMENT

Davits should be placed where they and the loads they are being used to hoist are free from obstructions. Lights and permanently installed equipment (CEMs) are examples of interferences that may cause an unsafe situation at the platform level (especially if the davit is free to swing). Power lines, conveyor belts, hot surfaces, sharp edges, and steam vents are examples of obstructions between the platform and the ground that may require special attention.

STATIC LINE USE

In situations where an obstruction is between the platform and the ground, a static line may help clear the obstruction. A static line is a rope or cable that is attached firmly at the ground and above the platform at an angle that clears the obstruction. Before being attached, the static line is passed through a metal ring, and the line carrying the load is attached to the ring. When the load is raised or lowered the metal ring is free to slide up or down the static line and thus maneuver the load around the obstruction. Static lines are also useful in windy conditions.

INSPECTION PRIOR TO USE

Prior to use, an existing davit and its components should be inspected and any required maintenance performed. Inspection and maintenance should include but is not necessarily limited to the following:

- The rope or cable used to hoist the load should be inspected for breaks or signs of wear and replaced if necessary.

- The pulley should be inspected for cracks, wear and corrosion. Corrosion on the face of the pulley that comes into contact with the rope or cable may abrade the rope or cable. The pulley's bearing or bushing may need to be lubricated.

- Nuts, bolts, and welds should be inspected for corrosion, wear and cracks that may indicate loss of structural integrity.

- Metal components should be inspected for corrosion, pitting and holes that may indicate loss of structural integrity.

- Electric motors and gear boxes used on powered hoists should be inspected and lubricated if necessary.

- Automatic stops on powered hoists should be inspected to ensure proper working condition if applicable.

In many cases this equipment is only used annually so it is important that the inspections are done prior to each use. While maintenance personnel may be responsible for inspection and maintenance of the davit and associated equipment, the stack testing personnel using the equipment could potentially be held responsible in the event of injury or damage, and should therefore take the time to look for potential problems.

DAVIT USE

The following is a two-part list of considerations to be cognizant of while using a davit to hoist equipment. The first part of the list pertains to davits where the hoisting is done manually (with a person pulling a rope), and the second part to powered systems:

Manual Systems:

- The rope used to hoist the load should be tied in a continuous loop as shown in Figure 1. When tied in a loop the weight of the rope on one side of the pulley is balanced by the weight on the other side. This is helpful when raising light loads; if the weight of the rope was not balanced then as the load neared the top, the weight of the rope returning to the ground would be greater than the weight of the load, and the load would accelerate towards the pulley. If the load was, for example, a wrench in a bucket, the bucket would accelerate towards the pulley and stop suddenly when it reached the pulley and could potentially eject the wrench which could then fall back to the ground and cause damage or injury.

- Before hoisting the first load, a suitable location should be found to tie off the rope with the load in the raised position.

- Gloves should be worn to protect the hands.

- The load on the davit is a little over twice the weight of the equipment being hoisted. If one hoists a 100 lb piece of equipment then the load on the davit is in excess of 200 lbs.

Powered Systems:

- Some powered systems that have buttons that must be manually held to raise or lower the load. Do not wedge anything against the button to operate the hoist.

- Automatic hoists should not be left unattended while in operation.

TEMPORARY DAVITS

Temporary davits should never be attached to the guard rail because the guard rail is safety equipment which should never have its integrity compromised. Attachment of temporary davits to the platform grating is also problematic because the grating is very often attached to the supporting structure with light weight attachments.

Driving and Towing

Tow Vehicle Procedures and Specifications

- Know your tow vehicle. Do not exceed the Gross Vehicle Weight Rating (GVWR) of your tow vehicle as specified by the manufacturer.
- The best tow vehicle is a 1 ton dually diesel with a crew cab. ¾ ton vehicle would be the minimum size for a small trailer.
- Check the GVWR rating on the hitch or bumper to make sure it meets or exceeds the GVWR rating on the trailer.
- Check hitch ball to make sure it is the same size as the trailer coupler. Also, the hitch ball should meet or exceed the GVWR of the trailer. Periodically lubricate the ball and visually check for any signs of deterioration. With excessive wear, hitch balls can come loose from the trailer coupler.
- If you are towing with a vehicle that did not come with a factory installed towing package, make sure to install a transmission cooler and a heavy-duty turn signal switch.
- Your tow vehicle should have properly installed fastener points (either links or rings) for the trailer's safety chains. These fastener points are part of the equalizer hitch. If you are using a bumper or a straight frame hitch, you may need to have fastener points added to the tow vehicle.
- Check your tow vehicle's tire pressure. When you add the hitch weight to tires that are improperly inflated, tread wear will be greatly accelerated.
- Make sure the mirrors are wide enough to see the back corner of the trailer. Most trucks have adequate mirrors, but most automobiles will require add-on extended mirrors that can be purchased at almost any auto or RV parts supplier.
- When you are hitched to the trailer, make sure both the tow vehicle and trailer ride level. If the hitch weight makes the tow vehicle "squat" in the rear, you will need to purchase an equalizer hitch to eliminate this problem. A tow vehicle that rides low in the rear will not steer properly and may cause damage to the rear axle, hubs, and tires from an overload situation.
- If you are towing with an automatic transmission, you should never tow in overdrive.

Trailer Procedures and Specifications

- Know your trailer. Do not overload. Stay within your Gross Vehicle Weight Rating (GVWR) capacity. Refer to your trailer's identification plate for the GVWR.
- Best trailer is a fifth wheel. Cargo trailer should be at least tandem axles. Axles should be rated the highest heavy duty rating.
- Follow the axle manufacturer's recommendations for checking lug nuts on wheels.
- If the trailer has been idle for several months, it is a good idea to grease the bearings as condensation can build up in the bearings. Regular use keeps the bearings free of moisture.
- Check tire pressure on trailer regularly and keep inflated per the PSI listed on the sidewall of the tire.
- Tires must be special trailer tires with maximum treads.
- Scale your trailer after it is loaded to make sure it does not exceed the GVWR. Make sure the hitch weight is between 10 and 15 percent of the trailers loaded weight. For example: A trailer that weighs 10,000 lb. loaded should have a hitch weight no less than 1,000 lb. and no more than 1,500 lb.
- Check your coupler periodically for adequate lubrication. A dry coupler and hitch ball will cause excessive wear. This will result in coupler or component replacement.
- Make sure you have a pin or padlock to secure the latching lever on the coupler. Without properly securing the latching lever, it could accidentally disengage allowing the coupler to jump off the ball.
- When coupling your trailer to your tow vehicle, be sure your battery is fully charged and the breakaway switch cable is secured to the tow vehicle.
- Make sure your trailer's safety chains have a rating that meets or exceeds the GVWR of the trailer. Securely latch the chains to links (or rings) on the tow vehicle. Be sure to cross the chains before you attach them to your tow vehicle. This crossing technique creates a cradle to catch the coupler should it disengage from the tow vehicle preventing it from dragging or plowing into the road. This will enable you to stop more safely in such an emergency. Do not allow the chains to drag on the road surface because over time this will weaken the chains and lessen their effectiveness. All ball coupler hitch trailers are required to have safety chains.
- Make sure all doors are closed and locked while in transit. Make sure all roof vents and windows are securely closed.
- Make sure your load has been properly secured so is does not shift while you are towing.
- Tie down straps are best for anchor points on the floor and the wall.
- Before each trip, check the operation of all lights on the tow vehicle and trailer.
- Before each trip check the trailer's brakes and make sure they are properly adjusted for the load you are carrying. Remember . . . it takes more room (and time) to stop a heavier loaded trailer than a light one. Anticipate stops and don't tailgate.

- Use common sense when towing a trailer. Watch your speed (maximum posted speed limit on any interstate highway is 60 mph). Make your turns a bit wider to accommodate your trailer.
- Have your tow vehicle and trailer safety checked annually.

Towing & Safety Tips

Instability

Swaying (or whipping) of a tow vehicle/trailer combination at low speeds may get worse as speed increases. If this happens, take your foot off the gas pedal. Steer straight ahead while manually applying the trailer brakes. Then brake gently after the combination has begun to stabilize itself. Stabilizer or weight equalizing bars will help reduce trailer sway and may also be required by law in some states.

Check cargo first to be sure that the trailer is loaded heavier in the front. If not, reposition the load so you get 10% of the total trailer weight on the tongue. Next, make certain the rear of the tow vehicle is not overloaded. Then check for wheel wobble on both vehicles caused by bearing failure, loose lug nuts or loose spindle nuts. Now check the tow vehicle's suspension alignment. Finally, make sure that you are not exceeding the recommended maximum speed limit for safety.
If the above instructions have been followed, instability should now be corrected. If not, something may be wrong with your tow vehicle.

Caution: Never increase speed when trailer is swaying or whipping.

Towing Tactics

With a trailer in tow, you're operating a vehicle combination that is longer, heavier and sometimes wider and taller, than you're used to. So you'll have to make some compensating adjustments in your normal driving practices. The following is advice in trailering tactics:

Take a "Shakedown Cruise". At least one short trial run before your trip will help familiarize you with your trailer's operating characteristics. It will also allow you to check the trailer's lights, brakes, hitch, etc., and let you know they are all working properly.

Slow down. Moderate to slower driving speeds put less strain on your tow vehicle and trailer and make for safer traveling. Allow extra time and space between your rig and traffic. You will need both when passing and stopping, especially if your trailer is not equipped with brakes.

Check rear view mirrors. Doing this frequently will let you know that your trailer is riding properly. We recommend outside rear view mirrors on both sides of your tow vehicle.

Swing wider. You need to make wider swings (turns) at curves and corners because your trailer's wheels are generally closer to the inside of a turn than the wheels on your tow vehicle.

Pass with extra care and caution. It takes more time and distance to get around a slower vehicle and return to the correct lane when you've got a trailer in tow.

Watch the wind direction and speed. To avoid swaying, be prepared for sudden changes in air pressure and wind buffeting when larger vehicles pass from either direction. Slow down a bit and keep a firm hold on your steering wheel.

Aim straight down your lane.

Avoid sudden stops and starts. This can cause skidding, sliding, or jackknifing, even if your trailer has brakes. Avoid quick stops while turning. Smooth, gradual starts and stops will improve your gas mileage.

Signal your intentions. Let surrounding vehicles know what you intend to do well in advance before you stop, turn, change lanes, or pass.

Shift to a lower gear. A lower gear will help ease the load on the transmission and engine when going over steep hills, sand, gravel, or dirt roads. If your tow vehicle has an "overdrive" gear, shifting out of overdrive to a lower gear may improve your gas mileage.

Always be courteous. Make it as easy as possible for faster moving vehicles to pass you. Keep to the right of the road and prepare to slow down if passing vehicles need extra time to return to their proper lane.

Don't tailgate. Allow at least one car and trailer length between you and the vehicle ahead for each 10 mph on your speedometer. Three seconds should be the minimum distance.

If a problem occurs don't panic. Stay calm and cool. Say you experience a sudden bumping or fishtailing. It may indicate a flat tire. Don't jam on the brakes or mash the accelerator in an attempt to drive out of it. Instead, come to a stop slowly as you keep driving in as straight a line as possible. If conditions permit, coast to a very slow speed and try to avoid braking, except when your wheels are straight ahead and your trailer and tow vehicle are in line with each other.

THE MAIN CAUSES OF TRAILERING ACCIDENTS

- Driver error.
- Failure to MATCH speed with weather and road conditions.
- Trailer sway due to improper loading—more or less than 10% cargo hitch weight.
- Failure to perform routine maintenance.

Winter Driving Tips

- Always keep the gas tank at least half full, and add gasoline antifreeze to every second tank.
- Top up antifreeze, transmission, brake and windshield-washer fluids.
- Use a matching set of all-season or snow tires that meet standards (see below).
- Make sure that tire valves are equipped with caps to keep out snow and ice.
- Dress properly - wear warm clothing.
- Carry a winter emergency kit that includes: extra antifreeze and windshield-washer fluid; a flashlight and extra batteries; blankets; a candle; matches; hazard markers or flares; a snow shovel; extra hats and mitts; and chocolate or granola bars.
- Check local weather and road conditions before leaving.
- If possible, tell someone where you are going and when you expect to arrive.
- Bring a map and be prepared to take an alternative route.
- Bring a cell phone.

Electrical Exposure

This section outlines requirements for electrical safety. It includes information on reducing or eliminating unsafe conditions that involve electrical equipment, faulty insulation, improper grounding, loose connections, defective parts, ground faults in equipment and unguarded energized parts. This section also is designed to guide in reducing accident potential in specific environmental conditions, particularly wetness and dampness, that contribute to electrical hazards.

Only properly trained workers should perform electrical work of any kind. Any electrical work should be done in accordance with the 1971 National Electrical Code (NEC), unless otherwise specified by OSHA regulations.

You should not work in areas where, in the course of work, you might contact an electrical power circuit, unless you have protected yourself against electric shock by de-energizing and ground the circuit or by using Ground Fault Circuit Interrupters (GFCI).

GENERAL GUIDELINES

ELECTRICAL

All electrical work shall be in compliance with the latest edition of the National Electrical Code, unless otherwise provided by OSHA regulations.

Work Near Electricity

- Only a trained electrician who is experienced with the National Electrical Code shall make electrical repairs and/or installations.
- No work shall be performed on or near unguarded electrical circuits unless a qualified person has tested the circuit to assure there are not live parts.
- Lockout/Tagout procedures are to be followed when the potential for employee exposure to stored energy exists.

Electrical Boxes/Panels

- Electrical receptacles shall be grounded.
- Circuit protectors, such as fuses or circuit breakers, shall be installed within the circuit to prevent excessive current flow.
- Security covers shall be installed on live electrical receptacle/panel boxes and the boxes shall be mounted and secured.

General

- Use either ground fault circuit interrupters as specified in 29 CFR 1926.404 (b)(1)(ii) or an assured equipment grounding conductor program as specified in 29 CFR 1926.404 (b)(1)(iii).
- Fuses and circuit breakers shall be located or shielded so that employees will not be burned or otherwise injured by their operation.
- Circuit breakers shall clearly indicate whether they are in the open (off) or closed (on) position.
- Check the number and use of other receptacles on the circuit you plan to use.
- Temporary wiring shall be removed immediately upon completion of testing or the purpose for which the wiring was installed.
- Flexible cords shall be used only in continuous lengths without splice or tap.
- Portable hand lamps should contain a metal shell.
- The operating voltage of exposed live parts of transformer installations shall be indicated by warning signs or visible markings on the equipment or structure.
- Worn or frayed electric cords or cables shall not be used.
- Extension cords shall not be fastened with staples, hung from nails, or suspended by wire.
- Controls that are to be deactivated during the course of work on energized or de-energized equipment or circuits shall be tagged.
- Equipment or circuits that are de-energized shall be rendered inoperative and shall have tags attached at all points where such equipment or circuits can be energized.
- Tags shall be placed to identify plainly the equipment or circuits being worked on.

Three wire extension cords must be used with portable electrical tools and equipment. They should be protected from damage, and should not be fastened with staples, hung from nails, or suspended from wires. Splices should have soldered wire connections with insulation equal to the cable. Worn or frayed electrical cords should not be used; they should be repaired, replaced or disposed of properly. Integrity of the ground wire should be checked quarterly or prior to use.

Except where bulbs are deeply recessed in the reflector, bulbs on temporary lights should be equipped with guards. Temporary lights must not be suspended from the electric cords unless they are designed for suspension.

Receptacles for attachment plugs such as outlets or extension cords should be of the approved concealed contact variety. Where different voltages or types of current are supplied, receptacles should be used that prevent interchanging attachment plugs.

Electrical cables in the work area should be covered or elevated to protect them from damage and becoming a tripping hazard. The non-current carrying metal parts of portable and/or plug connected equipment must be grounded properly.

ELECTRICAL GROUNDING

When temporary wiring is used on a job, either a Ground Fault Circuit Interrupter (GFCI) or an Assured Equipment Grounding Conductor Program (AEGCP) is required for protection. These requirements are in addition to other requirements for equipment grounding conductors.

Under ideal conditions, all 120-volt, single-phase, 15- and 20- ampere receptacle outlets on sites that are not a part of the permanent wiring of the building or structure should have approved GFCI.

Receptacles do not need to be protected with GFCI if they are on a two wire, single phase portable or vehicle mounted generator rated not more than 5kW, where the circuit conductors of the generator are insulated from the generator frame and all other grounded surfaces.

When working on a construction site where electric cord sets, extension cords or receptacle outlets are not included in the permanent building or structure wiring, and where GFCI's are not in use, make certain there is an AEGCP. The AEGCP should include the above items as well as any equipment that is connected by cord and plug which is either available for use or is being used.

- A trained and competent person(s) must be designated to implement the program.
- A daily inspection should be made of all cord sets, attachment caps, plugs and receptacles of cord sets, and any equipment connected by cord and plug. The inspection is necessary to determine external defects, deformed or missing parts, insulation damage, or indication of internal damage, any of which requires that the damaged or defective equipment not be used until proper repairs have been made.

Sampling probes must be grounded. Additional grounding may be required when testing Electrostatic Precipitators (ESPs) to prevent static discharge or probe weling.

UNKNOWN ELECTRICAL HAZARDS

To protect you from unknown electrical hazards and to comply with 29 CFR 1926.416, each resident project representative is responsible for finding live parts of electrical equipment or ungrounded voltage-carrying wires with which you could accidentally come in contact. If these conditions are shown to exist, appropriate protective measures must be taken before you begin work.

Fall Protection

Falls in both general industry and construction are one of the leading causes of workplace fatalities and serious injuries. To protect the safety of employees, a proactive approach is necessary to address fall hazards in workplaces through the use of selected fall protection controls.

These goals can be accomplished through (1) comprehensive fall hazard assessments; (2) proper selection, use and maintenance of fall protection controls; (3) employee fall protection training; and (4) periodic reviews of the effectiveness of fall protection programs.

Program Responsibilities

Management or Program Oversight is responsible for supporting the established policies and procedures of the program.

- Oversees the policies and procedures of the program
- Provides guidance on the requirements of the program
- Performs fall hazard assessments
- Selects and establishes standard operating procedures for fall protection controls
- Coordinates activities where fall hazards are present
- Provides fall protection safety training
- Notifies contractors of activities that involve fall hazards
- Evaluates the effectiveness of the program on an annual basis
- Assists in the design and selection of fall protection controls
- Understands the fall hazards and fall protection controls in their area
- Oversees activities where fall hazards are present

Employees are responsible for:

- Understanding the fall hazards associated with their job task, and
- Following established fall protection policies and procedures.

Fall Protection Procedures

Applicability

Fall hazards are present when either of the following conditions are present under general industry conditions:

- Work is conducted at unprotected heights at or exceeding 4 feet above the lower level, such as unprotected sides or edges of a walking or working platform, floor or wall openings, ramps and other similar locations.
- Work is conducted at unprotected heights less than 4 feet above the lower level, where dangerous equipment or processes are located below.

Fall Hazard Assessment

A comprehensive fall hazard assessment will be conducted to identify the location and relative fall hazard associated with the activity. Fall hazards can include:

- General work at unprotected heigh exceeding 4 feet and construction activities at unprotected heights exceeding 6 feet for, or above dangerous equipment or processes.
- Wall and floor openings.
- Employee elevating equipment.
- Railcars.
- Ladders

Inspection, Maintenance and Care

All fall protection equipment should be inspected to ensure the equipment is properly functioning. Equipment should be inspected at the following frequency:

Type of Equipment	Frequency of Inspection
Body Harness	Daily is suggested, but no less than weekly
Tie-offs	Daily is suggested, but no less than weekly
Platforms/Scaffolding	Daily / or before testing

All fall protection equipment found to be defective should be removed from service immediately until replaced or repaired.

All fall protection equipment should be cleaned and maintained in a good working order following each use.

All fall protection equipment should be stored in a clean and dry location following each use.

Employee Training

All employees required to use fall protection or exposed to fall hazards should be trained on the following:

- Identification and nature of fall hazards
- Means to minimize fall hazards
- Types and limitations of fall protection
- Use and care of fall protection
- Inspection of fall protection

Training will ensure the employee's understanding, knowledge and demonstrated skill to utilize the applicable fall protection equipment.

Training should be conducted prior to exposure to any fall hazards, as needed to ensure employees are properly trained in the use of the equipment, or to ensure employees are informed of any changes in fall hazards or changes in protective equipment.

Program Evaluation

The fall protection program should be reviewed on an semi-annual or annual basis to ensure the continued effectiveness of the policy and procedures. The program should be updated as needed, reflecting any changes in the policy and procedures as they occur.

EXAMPLE
FALL PROTECTION EVALUATION

Facility Name: ABC Company
Location: Durham, NC

Contact: Michael W. Hartman
Date of Evaluation: 2/3/2007

Location of Fall Hazard: Baghouse Area
Reason for Work: Air emissions using a cherry picker

Description of Fall Hazard:

X Work at Unprotected Heights Exceeding 4 Feet

- Ladders
- Lifts
- Wall or Floor Openings
- Other_____

Fall Protection Equipment Category

X Fall Arrest
- Suspension
- Other _____
- Positioning
- Retrieval

Equipment Required:

Type	***Equipment Location***	***Inspection***
Cross Arm Strap	Testing Trailer	Daily/Annual
Shock-Absorbing Lanyard	Testing Trailer	Daily/Annual
Full Body Harness	Testing Trailer	Daily/Annual

Location of Anchor Point: Basket
Description of Use Procedure: Put on full body harness while on the ground. On platform, attach cross arm strap to the appropriate anchor point on the basket, attach the lanyard to the strap, and attach the lanyard to the back of the harness.
Maitenance and Storage of the Equipment: Following each use, the fall protection equipment must be cleaned and stored by the user.
Limitations and Precautions: Not to exceed weight of basket; be on firm, level ground; be aware of any pipes, beams, or other physical hazards as you move the basket.

FALL PROTECTION TERMS

Anchorage - A secure point of attachment for lifelines, lanyards and deceleration devices.

Body Belt - A strap with means both for securing it about the waist and attaching it to a lanyard, lifeline or deceleration device for positioning of worker. Not a personal fall protection device.

Body Harness - Straps that secure about the person in a manner that distributes the fall arrest forces over at least the thighs, pelvis, waist, chest and shoulders with a means for attaching the harness to other components of a personal fall arrest system.

Connector - A device that is used to connect parts of a personal fall arrest system or position device system together.

Deceleration Device - Any mechanism, such as a rope grab, shock-absorbing lanyard or self-retracting lifeline, which services to dissipate a substantial amount of energy during the fall arrest, or otherwise limits the energy imposed on the employee during fall arrest.

Deceleration Distance - The additional vertical distance a falling person travels, excluding lifeline elongation and free fall distance, before stopping, from the point at which a deceleration device beings to operate.

Fall Arrest System - A system including but not limited to an anchor point, connection device and a body belt or body harness used to arrest an employee in a fall from a working level.

Guardrail System - A barrier erected to prevent employees from falling to a lower level.

Hole - A void or gap in the floor or other working surface.

Lanyard - A flexible line of rope, wire rope or strap that generally has a connector at each end for connecting the body belt or body harness to a deceleration device, lifeline or anchor point.

Lifeline - A component consisting of a flexible line for connection to an anchor point at one end to hang vertically (vertical lifeline), or for connection to anchor points at both ends to stretch horizontally (horizontal lifeline), and that services as a means for connecting other components of a personal fall arrest system to the anchor point.

Maintenance - "Maintenance", "repair", or "refurbishment". "Maintenance activities" can be defined as making or keeping a structure, fixture or foundation in proper condition in a routine, scheduled or anticipated fashion. This definition implies "keeping equipment working in is existing state, *i.e.,* preventing its failure or decline."

Opening - A gap or void in the wall or partition, through which an employee can fall to a lower level.

Positioning Device System - A body belt or body harness system rigged to allow an employee to be supported on an elevated vertical surface, such as a wall and work with both hands free while leaning backwards.

Rope Grab - A deceleration device that travels on a lifeline and automatically, by friction, engages the lifeline and locks to arrest a fall.

Self-Retracting Lifeline/Lanyard - A deceleration device containing a drum-wound line which can be slowly extracted from, or retracted onto, the drum under minimal tension during normal employee movement and which, after onset of a fall, automatically locaks the drum and arrests the fall.

Snaphook - A connector consisting of a hook-shaped member with a normally closed keeper, or similar arrangement, which may be opened to permit the hook to receive an object and when released automatically closes to retain the object.

Walking/Working Surface - Any surface, whether horizontal or vertical, on which an employee walks or works, including but not limited to floors, roofs, ramps, bridges runways and framework.

Source of Terms: OSHA Document 3146-1998, Fall Protection in Construction

Flare Testing

Guidance for Title 40, Code of Federal Regulations
Part 60, Section (§) 60.18
Flare Testing

Flare line testing is potentially much more dangerous than most sources since flares may contain highly flammable and/or toxic gases, the uncontrolled release of which can result in serious injury or death. Sampling programs must be designed to prevent an inadvertent release or personnel contact with flare gas while determining maximum flare tip velocity or collecting a net heating value gas sample. Testers must be trained and equipped to perform the work safely and properly respond to any emergency that may develop.

VELOCITY MEASUREMENT

When possible, in-line flow measurement devices should be used to eliminate the need to open the flare line. EPA Reference Method (RM) 2A, §2.1 and RM 2D, §2.1 contain the specification for flow rate measuring devices. These include positive displacement meters, turbine meters, rotometers, orifice plates, or other flow rate measurement devices. If a measurement device is present and it can be calibrated to meet the criteria this should be the first option pursued with the regulatory agency, even if the location does not meet ideal siting requirements.

If an in-line flow measurement device is not present a RM 2 S-type pitot designed to operate in a sealed system, also known as a packing gland probe, is the best method for measuring the velocity head (ΔP) in the flare line. Packing gland probes can be designed to fit through a valved opening as small as ½ inch (") inside diameter. The packing gland and a double-valve isolation system can effectively prevent leakage through the sample port. A probe restraint may be needed for high-pressure lines.

During normal operation a flare line may have very low flow, but the capacity for extremely high flow rates must be maintained to accommodate process upsets. During an upset, flammable and/or toxic gases may pass through the flare line under high pressure. In these cases, complete containment of the gas is absolutely necessary. The pitot/manometer system must

withstand the maximum potential pressure that may be generated. This may range from a few pounds per square inch (psi) to more than 100 psi. A thorough knowledge of the specific source is necessary to ensure the sampling equipment is adequate and testers must be trained for emergency shutdown situations.

GAS SAMPLING

Complete containment of the flare gas should be the primary concern when sampling flare lines. Evacuated sample containers or the pressure of the flare line are recommended for sample collection whenever possible. If pumps are employed, they must be designed to operate safely in a flammable atmosphere.

Since RM 18 is designed for determining emissions rather than concentrations of process gases, some modifications to the method are appropriate due to safety considerations. Stainless steel sample bombs that would not be suitable for determining part per million concentration levels may be acceptable, upon approval of the regulatory agency, for flare gas sampling. Glass sampling flasks may not be suitable. If flexible bags are used, proper precautions (e.g., a plastic carboy or other secondary container) must be taken to protect the bags from puncture and contain the gas if a leak develops. Special considerations should be given for sample shipment, especially if there will be substantial changes in ambient pressure, e.g., air freight or storage at elevated ambient temperatures.

Flat Roof Fall Protection

Flat roofs present special potential safety hazards, such as unprotected roof edges and weakened structures (skylights and glass fiber panels). People who work in elevated areas should be aware of the potential hazards associated with this type of work, including slips, trips and falls. They should be familiar in the identification of fall hazards, how to inspect facilities and equipment, and how to properly prepare for these hazards. Each person should inspect the area they are working in to identify any slip, trip or fall hazards. They should assess the conditions and determine the proper equipment needed to perform the job safely. Equipment should be inspected before each use. Housekeeping should be kept up to maintain a work area free of slip, trip and fall hazards.

GENERAL GUIDELINES

1. All work areas should be kept clean and orderly.
2. All aisles or passageways must be kept clear.
3. Any wall or floor openings should be identified and guarded appropriately.
4. All portable ladders and scaffolding should be thoroughly inspected before use and only used as specified by the manufacturer.

A. Roof Edge Guidelines

- Any employee involved in leading edge work (working closer than 7 feet to a roof edge) should have an appropriate positioning device system in place. The positioning system shall consist of a body harness, anchorage point, and connecting web or rope. This device shall be rigged to allow movement of the employee only as far as the edge of the work surface. This device shall be rigged such that an employee cannot free fall more than two feet. The positioning device shall be secured to an anchorage point capable of supporting at least twice the potential impact load of an employee's fall or 3,000 pounds, whichever is greater. Positioning system components are only to be used as part of a system and not to hoist materials.

- During roof work, it is recommended that a warning line system be utilized pursuant to 29 CFR 1926.502(f). A warning line system consisting of ropes and support stanchions, flagged at six foot intervals, should be utilized. The warning line should be suspended at 34-39 inches in height and at least 10 feet from the perimeter of the

roof. This will identify the area being worked in. Proper training should be provided in the setup and application of this warning line system.

B. Roof Lighting

- Roof lighting must be sufficient to illuminate the egress/ingress pathway and the work area to enable the workers to identify any tripping or fall hazards or obstacle that may result in bodily injury.

C. Roof Load

- Roof load ratings must be specified and assessed to support the anticipated plant, regulatory and sampling personnel and associated testing equipment weight.

- Unsafe load areas must be identified and barricaded.

D. Skylights

- Skylights and other roof weak points such as equipment lifting area covers, etc. must be easily identified and barricaded.

E. Weather

- All employees working on a roof must be aware of fall and projectable safety issues resulting from adverse weather conditions, such as wind, ice, snow, rain, extreme heat or cold, lightning, tornados, etc.

F. Plant Problems

- All employees must be aware of safety issues resulting from plant problems such as explosion, fire, smoke, etc. At least two roof egress routes must be identified in case the primary route is unattainable.

- The nearest safety showers, plant telephone and first aid areas must be identified prior to roof entry.

G. Barricades

Barricades are of three general types as follows:

- Fixed Barricade - Is solidly built structure designed to physically bar access to an area such as to protect a roof opening.

- Yellow Tape Barricade - Is used to encircle an area where construction activity is going on and access to the area is restricted. An individual may enter a yellow-tape barricade once he/she verifies it is safe to do so.

- Red Tape Barricade - Is used to encircle an area where construction activity is going on and access by unauthorized personnel is prohibited. Entry can only be granted by the personnel who erected the barricade.

- A barricade is considered to be up and functional when it completely encircles the area to be protected. A wall with no openings into the work area can be used as part of the barricade. If a side of the barricade is down or missing the barricade is considered down and non-functional.

- Barricades shall have signage on them indicating the name of the company erecting the barricade, who erected the barricade, date, nature of the hazard and PPE requirements for entry. Plain tags with the required information annotated on them are sufficient.

- Tags should be hung along direction of approach with a minimum of one tag per barricade side.

H. Roof Openings

- Roof openings must be guarded by a standard railing and toe boards or cover. In general the railing must be provided on all exposed sides, except at entrances to stairways. Typically, roof openings are hatchways, stairwells, or ladder openings. Additionally, a roof opening would measure more than 12 inches in it's least dimension.

- Roof holes into which anyone can accidentally walk into must be guarded either by a standard railing with toeboards on all exposed sides or a standard hole cover.

Typically a roof hole is a hole through which materials but not persons may fall, such as belt hole, pipe opening or slot opening. Additionally a roof hole will measure less than 12 inches but more than 1 inch in it's least dimension.

- Standard railing shall be 42 inches above opening, mid rail approximately half-way between opening and top rail, toe boards shall be a minimum of 4 inches in height.

- Hole covers may be used if the span of the hole can be covered by 4 feet x 8 feet of 3/4 inch marine plywood which is securely fastened at each corner to the roof and clearly labeled as a hole cover. Material can not be stacked/stored on top of a "in-use" hole cover. Greater spans will require more substantial hole covers.

- A metal hole cover can be used providing its weight-bearing capacity is greater than 3/4 inch marine plywood. Fastening and labeling requirements are the same.

- Open-side roofs or platforms, 6 feet or more above an adjacent roof or ground level shall be guarded by a standard railing, or equivalent, on all open sides except at entrances to ramps, stairways, or fixed ladder(s) or no one shall be closer than 7 feet to the edge.

- Runways 4 feet or more in height shall have standard railings on all open sides, except runways 18 inches or more in width used exclusively for special purposes may have one side omitted where operating conditions require. Fall protection may be required.

I. Extension Cords used on Roofs

- Extension cords shall be designed for exterior use and be of the three wire type. If a grounding plug is missing, the extension cord must be immediately removed from service and repaired/replaced. Worn or frayed cords shall not be used.

- Extension cords shall be protected from damage and shall not be fastened with staples, hung from nails, or suspended from wires. Extension cords shall not be strung across stair wells or walkways. Where possible they shall be run overhead from the power source to the work area keeping a minimum of 7 feet clearance between the cord and floor, walkway, etc.

- In performing any type of construction work, it must be assumed that all electrical power is "dirty power". Therefore, all extension cords/tool cords, etc. must be serviced by an approved ground-fault circuit interrupter (GFCI) either at the panel or the outlet. If a portable GFCI is used it shall be plugged in as close as possible to the power source, and the extension cord/tool cord plugged into the GFCI.

- If the male or female end of any drop cord, extension cord, cordset, etc. has been taped it may not be used on site. Repairs can be affected by removing the defective end and properly re-fastening it, or putting on a new end.

- Any extension cords with more than three repairs in the length of the cord are not permitted.

- Where temporary lighting is used, the extension cord and/or flexible cord must be designed for hard or extra-hard service (Types S, ST and So would be acceptable). Light bulbs/tubes should be of the "rough service" type.

J. Scaffolding Guidelines

OHSA guidelines for scaffolding construction should be followed. Ideally, the scaffolding should be erected by a qualified scaffolding contractor.

Scaffolding utilized during work should be thoroughly inspected and properly installed. The scaffolding system should include guard rails consisting of a top and mid rail located approximately halfway between. A toe board must be utilized if there will be people working the area around and below the scaffold. Frames should be stabilized by cross or diagonal braces which secure vertical members together laterally. Frames should be joined together vertically by compiling pins or equivalent means. Each platform on all working levels should be fully decked between the front uprights and the guardrail. The walking surface should not extend 9 ½ inches beyond the last support. If accessed from ground level, proper access ladders and entrances to the working level should be installed, with appropriate fall protection features. The use of scaffolding during air measurement projects may necessitate modifications to the railing system to properly operate the test equipment. Fall protection equipment may be required.

- Scaffolds shall be inspected before using, *i.e.*, for loose pins, toe boards, damaged components, etc.

- Scaffolds shall not be overloaded with men and/or equipment.
- Scaffold boards shall be kept free from materials that may cause tripping hazards, i.e., clean from grease, mud, loose material.

- Riding on scaffolds while being relocated is prohibited.

K Portable Ladders on Roof

1. Portable Ladder Guidelines

- Portable stepladders longer than 20 feet shall not be used.

- Stepladders shall be equipped with a metal spreader or locking device of sufficient size and strength to securely hold the front and back sections in open position.

- Single ladders longer than 30 feet shall not be used.

- Extension ladders longer than 60 feet shall not be used.
- Ladders shall be maintained in good condition at all times.

- Ladders shall be inspected frequently and those which have developed defects shall be withdrawn from service for repair or destruction and tagged or marked as “Dangerous, Do Not Use”.

2. Portable Ladder Safety Precautions:

- Proper use of ladders is essential in preventing accidents. Even a good ladder can be a serious safety hazard when used by workers in a dangerous way.

- Ladders shall be placed with a secure footing, or they shall be lashed, or held in position.

- Ladders used to gain access to a roof or other area shall extend at least 3 feet above the point of support.

- The foot of a ladder shall, where possible, be used at such a pitch that the horizontal distance from the top support to the foot of the ladder is one-quarter of the working length of the ladder (the length along the ladder between the foot and the support).

- The worker shall always face the ladder when climbing up or down.

- Ladders shall be used only for climbing purposes. Splicing of unlike ladders is prohibited. Ladders shall never be used in the horizontal position as scaffolds or work platforms.

- Ladders shall be used only for climbing purposes. Splicing of unlike ladders is prohibited.

- The top of a regular stepladder shall not be used as a step.

- Use both hands when climbing or descending ladders. Maintain 3 points of contact at all times.

- Metal ladders shall never be used near electrical equipment.

- Equipment should not be carried while using a ladder. Use a rope to hoist material if necessary.

- Metal type ladders shall never be used while working on or with energized electrical equipment. Place all ladders where they will not come in contact with electric wire or moveable equipment.

- When using ladders, they should be tied off and secured for falling (tied off at top). If unable to secure top, have co-workers hold while you are on the ladder. Protect ladder feet from roof damage.

- The use of buckets, chairs or other makeshift devices for work platforms is prohibited. Use a ladder or scaffold that is positioned on firm, level surface.

- When ascending or descending, always face the ladder; using both hands. Sliding down is prohibited.

- Avoid accumulation of oil, paint, etc., on the rungs of ladders. Clean rungs of the ladder before each use. Defective ladders shall be removed and tagged for non-use.

- Ladders shall not be leaned against loose material. Rails and footing on both sides of ladder shall be secure.

- When using ladders, they should be tied off and secured for falling (tied off at top). If unable to secure top, have co-workers hold while you are on the ladder. Protect ladder feet from roof damage.

- When ascending or descending, always face the ladder; using both hands. Sliding down is prohibited.

Handrails

I. STACK PLATFORMS

The guardrail system shall be continuous around the platform, and conform to OSHA requirements delineated in 29CFR 1926.500/3, Subpart M Fall Protection. The guard rail system, delineated in 1926.502 and appendix B, shall consist of a top and a middle rail and a toe board. The top rail shall be 42+/- 3 inches above the working grating/ deck with the middle rail at 20-22 inches above the grating. A toe board 6 inches in height shall be placed flush against the vertical poles on the platform support beams and the platform grating shall be extended to it. Vertical poles shall be placed around the platform perimeter 19 inches apart. The top and middle rails and vertical poles shall be able to sustain a force of 200 pounds. To prevent objects from falling between the openings in the guard rail system, the openings are to be covered with a mesh screen.

Modifying Platform to Accommodate Sampling Train

In the area of the sampling ports the top hand rail may be cut at 9.5 inches on either side of the center line of the sampling port. A vertical pole must be placed at the each end of the opening. A replacement segment of the rail a least 8 inches longer than the cut segment shall over lap the existing sections of rail on each side of the opening by 4 inches. One end of the new segment shall be fastened to the remaining rail on one side of the opening with a hinge and over lap the rail on the other side of the opening when placed in the downward position. There shall be a provision made to lock this side to the existing rail. **At no time shall the middle rail be cut**.

A heavy duty chain able to sustain a 200 pound force should be used to close the opening only temporarily. Since the chain can give it is not suggested for prolonged use.

The sampling ports in the stack shall be placed so that when a heated box with an extension is used, the maximum distance this box hangs below the top rail does not exceed 20 inches. This will ensure that the middle rail does not have to be cut out. If possible, the distance between the bottom of the sampling port and the top rail shall allow the use of a standard heated box / impinger box assembly without cutting the top rail.

The removable top rail segment shall be in place at all times except when having to move the sample train through the opening. After moving the train through the opening, the rail shall be replaced in the horizontal position and locked in place.

In the vicinity of the sampling port, an anchorage, as required in 1926.502, shall be provided for the person working in the area to attach the lifeline of the safety harness. Any person working on an elevated platform shall at all times wear a body harness with the lanyard/life line (with shock absorption capability) connected to an anchorage.

Hazardous Chemicals [1]

Chemicals Source Testers Bring To The Work Site

POLICY

The testing employee, his employers and the management and staff of the facility being tested, should be committed to providing a safe and healthful work environment, and to preventing injuries and illnesses caused by improper use of hazardous chemicals. This commitment must come from not only management, but also from each source tester. A written chain of responsibility is a big help.

The use of hazardous chemicals should be limited as much as practical. This may involve working to get regulatory agencies to approve a less hazardous chemical for a specific test method. One example is the effort made to restrict the use of methylene chloride and dinitrophenyl-hydrazine (DNPH), and instead use an alternate method that does not expose source testers to these hazards.

By following the basic guideline of OSHA's Hazard Communications rules, field personnel can minimize the risk from chemicals they must use.

A Summation of OSHA's Hazardous Communication Rules:

- Make sure all containers are labeled
- Obtain and distribute an MSDS for chemicals used
- Train personnel on the hazards & proper use of chemicals for routine jobs or special jobs (out of normal routine)
- Assign responsibility for following the rules

[1] Please note that some rules governing the transportation of hazardous chemicals have changed since September 11, 2001.

This section will discuss guidelines for safe...

- chemical handling
- transporting and storing chemicals
- chemical waste disposal
- spill cleanup
- handling of chemical-caused emergencies

GUIDELINES FOR CHEMICAL HANDLING

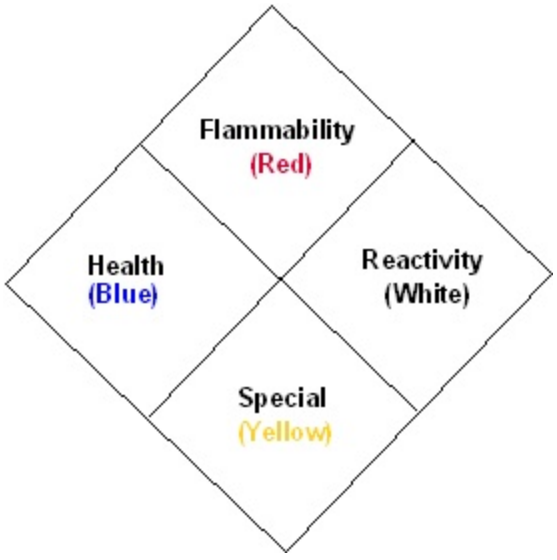
You'll need three main tools: knowledge, the right equipment, and good procedures.

Know what you are working with!

The hazards:

physical hazards from improper handling or storage (fire, explosion, etc).

health hazards are from exposure to the chemicals themselves. Effects can be reversible or irreversible.



Using the NFPA system, a chemical's hazards are described by four classes and assigned a scale from 0 to 4. There are four classes of hazardous chemicals.

Exposures

- *skin or eyes (absorption)*
- respiratory tract (inhalation)
- contamination of food or drink (ingestion)

INFORMATION

To assess how much you can safely be exposed to a chemical, look for limits in the MSDS for each chemical:

chronic exposures
OSHA Permissible Emission Limit (PEL), 8-hour time weighted average (TWA); NIOSH Threshold Limit Value (TLV)

acute exposures
short-term emission limit (STEL); ceiling value

Some chemicals are common allergens so an individual reaction may be different.

Other sources for information on the specific chemical you are working with are the container label, your supervisor, OSHA, local environmental authorities, the manufacturer of the chemical, and the site safety officer if the chemical is from a job site. Tables 1 and 2 (Appendices) describe common compressed gases and reagents used by source testers.

Get Training for Handling Chemicals

The training should cover routine work, using chemicals such as those listed in Tables 1 and 2. It should also cover non-routine work. In non-routine work look for the same type of information, but the source may be your supervisor or the site safety officer.

Take the necessary personal protection equipment

Use correct protective clothing and equipment

- Gloves, of the specific type safe for each chemical used
- Eye safety glasses, shields or chemical goggles
- Arm/leg/body shields
- Respirators
- Footwear

Ask your supervisor if you don't have a necessary item
Carry a chemical eye wash station with at least 15 minutes worth of water

Follow good procedures to make work area safe

Design the work area to reduce exposures
Make sample recovery area safe

- ventilation above, at, and below a person's breathing level for the various densities of chemicals
- build secure stands for all containers
- minimize clutter
- use tip resistant containers
- make sure to use the container that is resistant to each chemical

Vent analyzer exhausts from instrumental test systems away from work areas

Keep the workplace clean and uncluttered

Prevent ingestion of chemicals

- wash hands thoroughly before eating or smoking
- eat or smoke away from chemicals or hazards
- store food well away from chemicals

Be sure to use labels on secondary containers (wash bottles, waste bottles, sample bottles, and temporary storage, etc.) for every chemical that you transfer from the manufacturer's original container.

Guidelines for Transporting Chemicals

- Keep chemicals in chemical resistant containers
- Secure containers in the vehicle
- For the chemicals that source testers are likely to use, placards are needed if you carry over 1000 pounds total of cylinder gases and smaller amounts of hazardous chemicals.

Guidelines for Storing Chemicals

Know the class and hazard of each chemical
Check for the manufacturer's label or the secondary label
Separate chemicals and store in correct cabinet

- flammables
- non-flammables
- acids and bases separated
- corrosives
- toxics
- oxidizers
- compressed gas cylinders
    - secure from falling
    - valve protection cap in place when moving
- make sure the storage areas are safe
    - sturdy, secure to wall
    - away from light and heat
- Date each container and note date when chemical should be disposed of.

Disposal of Waste Chemicals

Disposal of wastes generated at the facility being tested is the legal responsibility of the facility, regardless of whether the tester or facility generated the waste. Therefore, disposal should be documented and performed in a manner consistent with the facility's HazMat Plan. Usually, the easiest way for both parties to ensure disposal is correctly performed is to turn over custody of wastes to the facility.

Guidelines for Spill Cleanup

Additional training in specific procedures should be implemented. Highlights of key procedures are given below.

General Procedure

- Assess the situation

  - Evacuate personnel to a safe area
  - Treat injuries
  - Stop the cause of the spill, and other nearby equip if necessary.
  - Identify material (booklets are available) (or review MSDS)
    - name & hazards
    - amount spilled
    - kit or materials needed to contain, availability

If you can or must deal with the spill

- Notify appropriate persons (site contact, colleague, authorities) and get phone assistance if possible
- Put on the necessary PPE
  - minimum: rubber gloves, face shield, respirator, lab coat, rubber boots
- Spills on persons
  - wash procedures for eye, face, arm, body, etc
  - remove contaminated clothing
  - get medical help
- Spills on property
  - contain with dike, roll, pillow, or pad, or loose non-reactive sorbent such as vermiculite, dirt, kitty litter, commercial material like Magicsorb
  - decontaminate or neutralize chemical with the appropriate spill control kit if appropriate
  - dispose of used sorbent materials, spill materials, contaminated clothing, chemical residues, in proper disposal bag
  - fill out incident/accident report

For Source testers the following spill control kits would be appropriate:

- flammable solvent kit or strong oxidizer kit
- all materials soaked with solvent are flammable
  - stop and remove all ignition sources
  - apply control chemicals outward to inward
  - mop up with rags or paper towels
  - place rags or towels in disposal bag

- Acid or caustic kit (neutralizer, mixer, pH indicator paper)
  - apply neutralizer (Spill X-A for acids, Spill X-C for caustics, Neutrasorb for both, or equivalent product); moving from outer perimeter inward
  - mix with scoop or brush
  - when foaming subsides, check pH:
    - add to 100 ml or water
    - if pH not between 3 and 10 add more neutralizer to spill and recheck
    - when pH between 3 and 10, dispose of all toxic kit

Guidelines for Handling Chemical-Caused Emergencies

Fire

Know what caused the fire
Use proper extinguisher
Get help

Fumes

Remove injured people to fresh air
Close containers, increase ventilation, open windows or doors
Evacuate the area

Eye Contact

Flush at the portable or plant eye wash station

Skin Contact

Drench skin and clothing
Remove contaminated clothing

See Appendix D for:

Table 1: Hazardous Chemicals – Compressed Gases

Table 2: Hazardous Chemicals - Reagents

The tables have information on the chemicals (including compressed gases) that source testers use and that would be considered hazardous according to EPA 40 CFR Part 261.

Also refer to Appendix H, the NIOSH Pocket Guide to Chemical Hazards (which is a separate folder on the CD.)

Hoisting Requirements

1.0 **Hoisting** (also read DAVITS, Chapter 6)

Stack sampling usually necessitates raising and lowering equipment, replacement probes and supplies to and from the sampling sites. This section will discuss these requirements and the advantages provided by block and tackle. Hoisting and lowering stack sampling equipment safely requires:

- Rope and gloves
- A clear path in which to raise and lower the equipment
- A reliable method of stopping or controlling the rate of descent
- A pulley or block and tackle for lifting heavy equipment
- Support for the hoisting device
- Methods of attaching loads
- Reliable hooks and ropes

Safe use of rope requires sturdy gloves for protection of the hands and for a secure grip on the rope. Gloves with leather palms are usually effective.

All overhead hoists in use shall meet the applicable requirements for construction, design, installation, testing, inspection, maintenance, and operation, as prescribed by the manufacturer.

Hoisting and lowering loads safely also requires communication and coordination between the person hoisting the load and the person guiding or receiving the load. If distances are great and ambient noise levels are high, the team may need to have both visual and audible signals.

1.1 Clear Path

Hoisting equipment up to a sampling site requires a clear vertical path that is unobstructed and wide enough for safe passage of the equipment that has to be hoisted. If there is no clear path that can be used for hoisting, it will take a lot more effort to transport the equipment up to the sampling site without risk of damage.

To prepare for hoisting equipment and supplies up to the sampling site, determine whether there is a clear path for hoisting or what route will have to be followed. This information should be obtained as soon as possible, either during the initial visit or as part of a pre-sampling or preliminary survey. The hoist shall only be installed in locations that will permit the ground operator to stand clear of the load at all times.

1.2 Hoisting Procedure

Before lifting any loads up to the sampling site, the hoisting area should be roped off or marked to warn pedestrians. Access to the hoisting area should be limited to the employees doing the hoisting or guiding the load, and the personnel must be wearing hard hats.

The rope or signs should be removed only after the hoisting has been completed and there is no danger of tools or equipment falling, or after the sampling has been completed. You may have to remove the signs and barricades around the hoisting area immediately after you complete the hoisting should the plant need to use the area for work or for traffic. No one should be directly under a load being hoisted, even if block and tackle are being used.

If possible, when loads are lifted, the hoisting line should be directly above the load so that the load is lifted straight up from its resting position. Pulling a load sideways as it is being lifted may cause it to swing and damage the load.

To keep loads from swinging or blowing while they are being hoisted, a tail line or guideline is recommended for control. The tail line or guideline is controlled by a crew member on the lower level at the hoisting site.

1.3 Controlling the Rate of Descent

Controlling the rate of descent of a load is important to prevent damage to the load or injury to personnel. If equipment is lowered directly on rope by hand or over a simple pulley, personnel could lose their grip and drop the load or burn their hands on the rope as the load accelerates downward. Although the rate of descent can be controlled best by use of a power-driven hoist or a block and tackle, a load can be lowered safely on a rope if the controlling end of the rope is looped around a support, such as a railing or post, so that friction can be used for braking.

1.4 Pulleys, Block, and Tackle

Although hoisting without pulleys is common in stack sampling work, use of one or more pulleys is recommended. Using a pulley for hoisting a load will usually reduce the strength required for hoisting, and may allow the person hoisting the load to work from a safer position. Pulleys and rigging should be standard equipment for stack sampling crews.

The supporting structure to which the hoist is attached shall have a safe working load equal to that of the hoist. The support shall be arranged so as to provide for free movement of the hoist and shall not restrict the hoist from lining itself up with the load. Sites over 50 feet high and those which are sampled regularly should have a pulley support installed. Some companies have permanently installed gallows frames and pulleys in such locations. The condition of frames and supports should be checked before using them, particularly in corrosive atmospheres.

A block and tackle is a combination of rope and two pulleys used to reduce the amount of force needed for lifting. If heavy loads need to be lifted to stack sampling sites, or controlled carefully on long lifts, the job can be done with less stress on the crew by use of block and tackle. The reduction of force required to lift a load with block and tackle is offset by the need for longer rope and the time to pull it through the pulleys.

Rigging block and tackle can be accomplished by placing the blocks or pulleys close together in the same relative position as they will be used, and threading the end of the coiled rope through the pulleys to the connecting point on one of the pulleys. The blocks can then be pulled apart as needed without kinking or tangling the line.

The recommended storage procedure for rope used in block and tackle is to pull the blocks together, coil the rope, and store the coiled rope with the end on the bottom and the block and tackle on top. With this procedure, the block and tackle are ready to use without tangling or kinking of the rope.

1.5 Hooks and Other Devices for Attaching Loads

Hoisting ropes should be provided with hooks to be used for reattaching loads. All hooks used for hoisting should have locking safety catches to keep loads attached to the hook until the safety catch is released. The safety catch is designed to prevent the load attachment or supporting eye or line from slipping out of the eye of the hook. The hook used for hoisting loads

should be strong enough to hold the load without bending out of shape. If carabiners are used, only the locking type should be used to prevent accidental opening. Use only load-rated carabiners large enough for the rope and lead.

1.6 Loads

Loads to be hoisted should have well-attached connections (such as an eye or sturdy handle) for the hoisting hook or the hoisting line. If loads do not have connections, or if a half-hitch is not employed, the loads should be supported in slings or be lashed so that the load will not shift or drop during the hoisting and lowering.

When hoisting probes or other equipment without a specific attachment point, it is safer to provide a separate sling or binding rope than to use the hoisting rope to wrap or tie the load. The most commonly used sling is composed of two lengths of rope with a galvanized ring spliced into each end of each rope. To use the sling, one length is passed under each end of the load and the four ring eyelets are hooked onto the tackle hook of the hoisting line.

1.7 Rope

The rope needs to be strong enough to support the load to be lifted, and large enough in diameter to allow a firm grip for the load to be lifted. Care should be taken to avoid kinking or damaging the rope, getting it wet, or dragging it in the dirt. If the rope gets dirty, it should be hosed off and then loosely coiled to dry. If the rope must be passed over sharp corners or edges, the sharp corners or edges should be padded or protected with chafing gear to prevent damage to the rope.

The rope should be routinely inspected for wear, breaks, or other defects either prior to each use or after each use (to save time when the rope is needed). Manila sisal rope may need to be replaced routinely or at least yearly if it is used often or gets wet frequently. Rope that is rotten, frayed, or severely worn is not reliable, is not safe, and should not be used.

Lab Ventilation, Hoods

Section 10 Laboratory Ventilation

10.1 Overview

Satisfactory lab ventilation is required to reduce laboratory worker exposure to chemicals during routine laboratory operations, to purge the laboratory of vapors or fumes in the event of a major chemical spill, and to control laboratory temperature, humidity, and air quality at desired levels. Lab ventilation objectives are accomplished with three types of ventilation systems or equipment as described below:

- **General Ventilation** refers to the heating, ventilation, and air conditioning (HVAC) system that conditions the air in the laboratory work area. A properly designed chemical laboratory will include a high volume exhaust fan for emergency use as part of the HVAC system. The nature of certain laboratory operations may require the use of negative or positive pressure work environments or the use of air purification systems on work area air supply and exhaust systems.

- **Local Exhaust Systems** are often used to provide ventilation in the immediate vicinity of a source of contaminant exposure. For example, the burner area on an atomic absorption spectrophotometer is typically vented directly to the outdoors to reduce chemical contamination and heat accumulation in the laboratory. Similarly, a temperature-programmed gas chromatograph (GC) will be equipped with a local ventilation device to remove GC oven heat from the laboratory. Chemical storage cabinets are often ventilated to prevent the accumulation of fumes or vapors in the cabinet.

- **Laboratory Hoods** are specially designed local ventilation devices that facilitate the safe and proper performance of specific laboratory operations. There are a variety of hood types and designs. It is essential to match hood type and design with the anticipated laboratory operation to provide worker protection. For example, chemical work must be conducted in a fume hood and not a biological materials

hood. Furthermore, hood design must be matched to the specific task with consideration of temperature, chemical reactivity, explosivity, and corrosivity.

For each laboratory ventilation system component to function properly, the entire ventilation system should be designed and planned with consideration of the component parts. This requirement, while sounding nice on paper, has little bearing on the reality of the emission testing laboratory business. Very few fixed-base emission testing laboratories have been designed from the ground-up. Furthermore, successful emission testing companies develop additional laboratory capabilities as their business grows. As a result, emission testing laboratories must give special attention to laboratory ventilation issues when they consider facility layout and the addition of new analytical capabilities.

Field deployable analytical facilities (*i.e.*, mobile laboratories, sample train recovery facilities, temporary trailers, etc.) also require appropriate attention to ventilation system design. While there are exceptions, effective ventilation systems for field deployable analytical facilities are best achieved by narrowing the application of the mobile unit. For example, it is easier and less expensive to design an effective ventilation system for a trailer outfitted for either instrumental test method analyses or EPA Method 29 recovery than to try to accommodate both in a single design. Providing proper ventilation systems for simultaneous instrumental analysis and Method 29 recovery in a single mobile facility design would prove complicated and expensive; however, it is possible that the same mobile platform could be cost-effectively configured to accommodate the separate performance of instrumental analysis and Method 29 recovery work.

10.2 Ventilation Regulations, Standards, and Guidance

Despite the importance of ventilation in laboratory operations, there are very few federal regulations that govern laboratory ventilation; however, several organizations publish standards and guidance, primarily for fume hood design, operation, and testing. The following list details some of the more important regulations, guidance, and standards related to laboratory ventilation:

- **OSHA 1910.94.** (OSHA – Occupational Safety and Health Administration) This is a general ventilation standard applicable to all industries. Emission testing laboratories may find the sections that address local ventilation systems useful.

- **OSHA 1910.1450.** This regulation governs chemical exposure to hazardous chemicals in the laboratory and provides specific language about ventilation. Key provisions are highlighted below:

  - ***General Ventilation:*** Lab operators should provide a source of air for breathing and input to local ventilation devices (lab workers will find the requirement for a source of breathing air valuable and emission testing company managers may find that this recommendation improves laboratory productivity!). Four-to-twelve air changes per hour is considered an acceptable ventilation level. There is a recommendation for periodic evaluation of the ventilation system (every 3 months) and when changes in local ventilation system components are made.

  - ***Hoods:*** Lab operators should provide 2.5 linear feet of hood space per person for every 2 workers that spend most of their time working with chemicals. Each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use of the hood.

  - ***Other Local Ventilation Devices:*** Ventilated storage cabinets, canopy hoods, instrument exhausts, etc. should be provided as needed and each should have a separate exhaust duct.

  - ***Emergency Ventilation Systems:*** OSHA does not set forth a recommendation for these devices, but a number of references suggest that an emergency ventilation system be sized to provide complete ventilation of the laboratory space in five minutes or less.

- **ANSI/AIHA z9.5.** (ANSI – American National Standards Institute; AIHA – American Industrial Hygiene Association). This is a non-binding standard that establishes an average face velocity requirement of 80 to 120 feet per minute. It is important to note that this standard is currently (First Quarter 2001) being revised. There are arguments about the validity of face velocity as an indicator of fume hood performance and the revised standard is expected to address these arguments. Further, the revised standard is expected to address ductless fume hoods and provide recommendations for work practices conducted in fume hoods.

- **ASHRAE-110.** (ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers) This standard sets forth a protocol for testing fume hood

performance that consists of face velocity measurement, flow visualization, and tracer gas tests.

Note that certain states, California and Wisconsin for example, have regulations that address the laboratory workplace. It should also be noted that some local agencies have addressed laboratories as emission sources and are requiring source registration and permitting in some cases. Thus, it is possible for ventilation systems associated with both fixed and mobile emission testing operations to be subject to local regulatory requirements. The reader is cautioned to evaluate local requirements regarding laboratory ventilation systems when establishing laboratory operations.

10.3 Ventilation Testing Protocols

The complete testing of laboratory ventilation systems is beyond the scope of this document but thoroughly described in various editions of "Industrial Ventilation: A Manual of Recommended Practice" published by the American Conference of Governmental Industrial Hygienists.

The ASHRAE protocol for testing fume hoods is highlighted below:

- **Face Velocity:** The hood sash should be opened fully or to the maximum opening/working location indicated by the manufacturer. A grid pattern is formed across the hood opening by dividing the vertical and horizontal dimensions such that a series of equal area zones are obtained. A calibrated anemometer (swinging vane design) is placed at the center of each zone (sounds like a traverse point, doesn't it?) and the reading is recorded. The average of all measurements is determined and compared with the recommended value of 80 to 120 feet per minute. *Readers are cautioned that even though an average face velocity may be recorded in the 80 to 120 feet per minute range, this does not mean that the hood is providing adequate protection for the hood user.*

- **Flow Visualization:** This two-part test involves the use of smoke tubes to establish airflow patterns at and near the face of the hood.

- **Tracer Gas Test:** This is a quantitative procedure in which a mannequin, outfitted with a gas detector in its mouth, is placed in front of the hood. Sulfur hexafluoride is then metered into the hood. The gas detector placed in the mannequin's mouth then measures the concentration of sulfur hexafluoride that escapes from the hood.

While the face velocity and flow visualization tests are within the capabilities of any firm that uses a fume hood, the quantitative tracer gas test procedures are not readily available. Additionally, there are arguments that tracer gas studies involving mannequins provide little value because the mannequins do not really simulate human activity at the fume hood.

Hood test procedures continue to evolve and some laboratories have found that the use of face velocity and flow visualization tests, coupled with other tests, address their needs for ensuring the safety of laboratory workers. A qualitative supplemental test involves the use of dry ice that is placed in a container of water that is placed in the fume hood. The capture of carbon dioxide vapor that spills from the container out onto the work surface can be easily visualized and documented. Quantitative tests involve the use of personal sampling pumps and NIOSH (National Institute of Occupational Safety and Health) or OSHA sampling protocols to document worker exposure to substances used in the laboratory. Optimally, an emission testing laboratory will rely on a combination of qualitative and quantitative tests that reflect the nature of hood use in the laboratory.

10.4 Additional Information

The following sources provide additional information about laboratory ventilation systems, equipment, and standards:

1. American Conference of Governmental Industrial Hygienists, Industrial Ventilation (latest edition), 6500 Glenway Avenue, Bldg. D-7, Cincinnati, Ohio 45211-4438.
2. American National Standards Institute, Inc., Laboratory Ventilation Standard. ANSI/AIHA z9.5-1992, American National Standards Institute, N.Y. 1979.
3. American Industrial Hygiene Association, Laboratory Ventilation Standard. ANSI/AIHA z9.5-1992, 2700 Prosperity Avenue, Suite 250, Fairfax, VA 22031.
4. American Society of Heating, Refrigeration and Air Conditioning Engineers, Standard 110-1995 Method of Testing Performance of Laboratory Fume Hoods, 1791 Tullie Circle, NE, Atlanta, GA 30329.
5. Occupational Safety and Health Administration.

   29 CFR 1910.94 – General Ventilation Standard

   29 CFR 1910.1450 – Chemical Exposure to Hazardous Chemicals in the Laboratory

6. National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

Fire Protection for Laboratories Using Chemicals NFPA-45. 1982
Safety Standard for Laboratories in Health Related Institutions, NFPA, 56c, 1980.
Fire Protection Guide on Hazardous Materials, 7th edition, 1978.

7. Scientific Apparatus Makers Association (SAMA). Standard for Laboratory Fume Hoods, SAMA LF7-1980, 1101 16th Street, NW, Washington, DC 20036.

Manlift Criteria

(includes cranes, cherry pickers, and hoistable platforms)

Here are some elements for stack samplers to observe. These are in addition to the OSHA regulations reproduced later in this section.

- The manlift should be operated by an operator trained for that specific manlift.
- All movement (positioning) should take place while the manlift is in the lowest non-extended position.
- All OSHA construction rules apply.
- A body harness system is required to be worn at heights above 6 feet.
- Overhead hazards should be noted and minimized, *i.e.,* power lines, I-beams, steam vents, etc. Where stack samplers may use a manlift probably is not normal for the plant personnel.
- Using manlifts to provide access to an elevated stationary platform is dangerous and should not be attempted unless there is no other way. A body harness system is mandatory.
- Never overload a manlift. See manufacturer's limits on the manlift.
- Two-way communication, *i.e.,* radios, are advisable.
- Chock and block all positioning wheels prior to ascent.
- While most samplers use the manlift to support the sampling train, caution must be taken as to the following:
    - Precautions should be taken that the weight of the probe and train will not cause the manlift or the sampling train to fall. Safety chains are advisable.
    - Care should be taken around hot probes, boxes and electrical outlets as there is no where to go to remove yourself from the hazard.
    - Watch that separate power lines are not caught in sharp metallic objects or other areas which might cause an electrical short.
    - Use of ground fault interrupters is advised.
    - Exhaust hazardous gases to a safe area.

Crane or Derrick Suspended Personnel Platforms

U.S. Department of Labor

Occupations Safety and Health Administration

OSHA 3100 (1993 revised)

INTRODUCTION

Using cranes or derricks to hoist personnel poses a significant risk to employees being lifted. To help prevent employee injury or death, the Occupational Safety and Health Administration (OSHA) regulation, Title 29 Code of Federal Regulations 1926.550, limits the use of personnel hoisting in the construction industry and prescribes the proper safety measures for these operations.

Personnel platforms that are suspended from the load line and used in construction are covered by 29 CFR 1926.550(g). In addition, there is no specific provision for suspended personnel platforms in Part 1910. The governing provision, therefore, is general provision 1910.180(h)(3)(v), which prohibits hoisting, lowering, swinging, or traveling while anyone is on the load or hook. OSHA has determined, however, that when the use of a conventional means of access to any elevated work site would be impossible or more hazardous, a violation of 1910.180(h)(3)(v) will be treated as "de minimis" if the employer has complied with the provisions set forth in 1926.550(g)(3), (4), (5), (6), (7), and (8).

The OSHA rule for hoisting personnel is written in performance-oriented language that allows employers flexibility in deciding how to provide the best protection for their employees against the hazards associated with hoisting operations and how to bring their work sites into compliance with the requirements of the standard.

This booklet discusses OSHA's requirements for hoisting personnel by crane or derrick in the construction industry, prescribes the measures employers must take to bring their work operations into compliance, and describes safe work practices for employees; ***but it is not a substitute for the actual OSHA rule.***

CRANE AND DERRICK OPERATIONS

The OSHA rule ***prohibits*** *hoisting personnel by crane or derrick* ***except*** *when no safe alternative is possible. Based on the review of the record, OSHA determined that hoisting with crane- or derrick-suspended personnel platforms constitutes a significant hazard to hoisted employees and must not be permitted unless conventional means of transporting employees are not feasible or unless they present greater hazards. OSHA determined that compliance with the provisions of this standard will provide the best available protection for personnel being hoisted by these platforms in those limited situation where such hoisting is necessary.*

Where conventional means (e.g., scaffolds, ladders) of access would not be considered safe, personnel hoisting operations, which comply with the terms of this standard, would be authorized. OSHA stresses that employee safety — not practicality or convenience — must be the basis for the employer's choice of method.

Cranes and derricks used to hoist personnel must be placed on a firm foundation and the crane or derrick must be uniformly level within 1 percent of level grade.

The crane operator must always be at the controls when the crane engine is running and the personnel platform is occupied. *The crane operator also must have full control over the movement of the personnel platform. Any movement of the personnel platform must be performed slowly and cautiously without any sudden jerking of the crane, derrick, or the platform. Wire rope used for personnel lifting must have a minimum safety factor of seven. (This means it must be capable of supporting seven times the maximum intended load.) Rotation resistant rope must have a minimum safety factor of ten.*

When the occupied personnel platform is in a stationary position, all brakes and locking devices on the crane or derrick must be set.

The combined weight of the loaded personnel platform and its rigging must not exceed 50 percent of the rated capacity of the crane or derrick for the radius and configuration of the crane or derrick.

INSTRUMENTS AND COMPONENTS

Cranes and derricks with variable angle booms must have a boom angle indicator that is visible to the operator. Cranes with telescoping booms must be equipped with a device to clearly indicate the boom's extended length, or an accurate determination of the load radius to be used during the lift must be made prior to hoisting personnel. Cranes and derricks also must be equipped with (1) an anti-two-blocking device that prevents contact between the load block and overhaul ball and the boom tip, or (2) a two-block damage-prevention feature that deactivates the hoisting action before damage occurs.

PERSONNEL PLATFORMS

Platforms used for lifting personnel must be designed with a minimum safety factor of five and designed by a qualified engineer or a qualified person competent in structural design. The suspension system must be designed to minimize tipping due to personnel movement on the platform.

Each personnel platform must be provided with a standard guardrail system that is enclosed from the toeboard to the mid-rail to keep tools, materials, and equipment from falling on employees below. The platform also must have an inside grab rail, adequate headroom for employees, and a plate or other permanent marketing that clearly indicates the platform's weight and rated load capacity or maximum intended load. When personnel are exposed to falling objects, overhead protection on the platform and the use of hardhats are required.

An access gate, if provided, must not swing outward during hoisting and must have a restraining device to prevent accidental opening.

All rough edges on the platform must be ground smooth to prevent injuries to employees.

All welding on the personnel platform and its components must be performed by a qualified welder who is familiar with weld grades, types, and materials specified in the platform design.

LOADING

The personnel platform must not be loaded in excess of its rated load capacity or its minimum intended load. Only personnel instructed in the requirements of the standard and the task to be performed — along with their tools, equipment, and materials needed for the job — are allowed on the platform. Materials and tools must be secured and evenly distributed to balance the load while the platform is in motion.

RIGGING

When a wire rope bridle is used to connect the platform to the load line, the bridle legs must be connected to a master link or shackle so that the load is evenly positioned among the bridle legs. Bridles and associated rigging for attaching the personnel platform to the hoist line must not be used for any other purpose.

Attachment assemblies such as hooks must be closed and locked to eliminate the hook throat opening; an alloy anchor-type shackle with a bolt, nut, and retaining pin may be used as an alternative. "Mousing" (wrapping wire around a hook to cover the hook opening) is not permitted.

INSPECTING AND TESTING

A trial lift of the unoccupied personnel platform must be made before any employees are allowed to be hoisted. During the trial lift, the personnel platform must be loaded at least to its anticipated lift weight. The lift must start at ground level or at the location where the employees will enter the platform and proceed to each location where the personnel platform is to be hoisted and positioned. ***The trial lift must be performed immediately prior to placing personnel on the platform.***

The crane or derrick operator must check all systems, controls, and safety devices to ensure the following:

- *They are functioning properly.*
- *There are not interferences.*

- *All boom or hoisting configurations necessary to reach work locations will allow the operator to remain within the 50-percent load limit of the hoist's rated capacity.*

If a crane or derrick is moved to a new location or returned to a previously used one, the trial lift must be repeated before hoisting personnel.

After the trial lift, the personnel platform must be hoisted a few inches and inspected to ensure that it remains secured and is properly balanced.

Before employees are hoisted, a check must be made to ensure the following:

- *Hoist ropes are free of kinks.*
- *Multiple part lines are not twisted around each other.*
- *The primary attachment is centered over the platform.*
- *There is no slack in the wire rope.*
- *All ropes are properly seated on drums and in sheaves.*
- *Safety equipment, such as respirators, gloves, radios, etc., are on the platform.*

Immediately after the trial lift, a thorough visual inspection of the crane or derrick, the personnel platform, and the crane or derrick base support or ground must be conduced by a competent person to determine if the lift test exposed any defects or produced any adverse effects on any component or structure. Any defects found during inspections must be corrected before hoisting personnel.

When initially brought to the job site and after any repair or modification, and prior to hoisting personnel, the platform and rigging must be proof tested to 125 percent of the platform's rated capacity. This is achieved by holding the loaded platform — with the load evenly distributed — in a suspended position for 5 minutes. Then a competent person must inspect the platform and rigging for defects. If any problems are detected, they must be corrected and another proof test must be conducted.

Personnel hoisting must not be conducted until the proof testing requirements are satisfied.

PRE-LIFT MEETING

The employer must hold a meeting with all employees involved in personnel hoisting operations (crane or derrick operator, signal person(s), employees to be lifted, and the person responsible for the hoisting operation) to review the OSHA requirements and the procedures to be followed before any lift operations are performed.

This meeting must be held before the trial lift at each new work site and must be repeated for any employees newly assigned to the operation.

SAFE WORK PRACTICES

Employees, too, can contribute to safe personnel hoisting operations and help to reduce the number of accidents and injuries associated with personnel hoisting operations. Employees must follow these safe work practices:

- *Use tag lines unless their use creates and unsafe condition.*
- *Keep all body parts inside the platform during raising, lowering, and positioning.*
- *Make sure a platform is secured to the structure where work is to be performed before entering or exiting it, unless such securing would create an unsafe condition.*
- *Wear a body belt or body harness system with a lanyard. The lanyard must be attached to the lower load block or overhaul ball or to a structural member within the personnel platform. If the hoisting operation is performed over water, the requirements 29 CFR 1926.106 — Working over or near water — must apply.*
- *Stay in view of, or in direct communication with, the operator or signal person.*
- *Know the hand signals.*

Crane and derrick operators must follow these safe work practices:

- *Never leave crane or derrick controls when the engine is running or when the platform is occupied.*
- *Stop all hoisting operations if there are indications of any dangerous weather conditions or other impending danger.*

- *Do not make any lifts on another load line of a crane or derrick that is being used to hoist personnel.*

MOVEMENT OF CRANES

Personnel hoisting is prohibited while the crane is traveling except when the employer demonstrates that this is the least hazardous way to accomplish the task or when portal, tower, or locomotive cranes are used.

When the cranes are moving while hoisting personnel, the following rules apply:

- *Travel must be restricted to a fixed track or runway.*
- *Travel also must be limited to the radius of the boom during the lift.*
- *The boom must be parallel to the direction of travel.*
- *There must be a complete trial run before employees occupy the platform.*
- *If the crane has rubber tires, the condition and air pressure of the tires must be checked and the chart capacity for lifts must be applied to remain under the 50-percent limit of the hoist's rated capacity. Outriggers may be partially retracted as necessary for travel.*

Compliance with the common-sense requirements of the OSHA standard and ***the determination that no other safe method is available*** *should greatly reduce or eliminate the injuries and accidents that occur too frequently during personnel hoisting operations.*

Maximum Numbers of Hours in a Work Day and Work Week

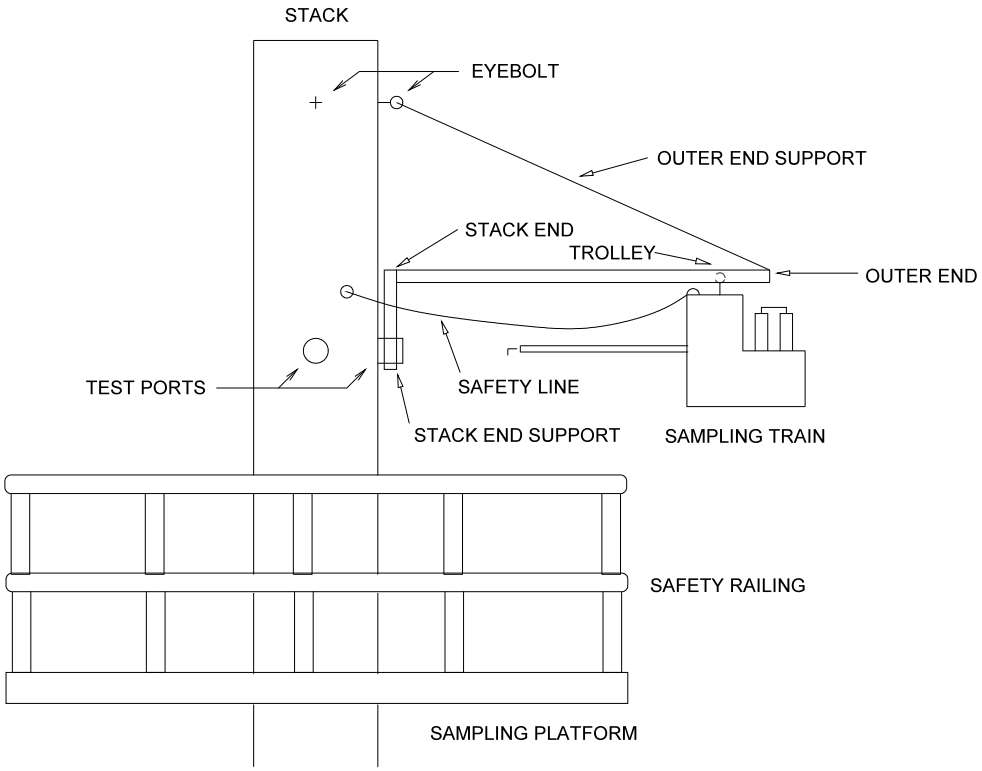
Generally speaking, stack testing is conducted in light to heavy industrial areas with numerous known and often unforeseeable hazards. Historically, stack test crews have often been expected to work as many hours as are necessary to accomplish the target goals of the day. This is not standard practice in almost any other industry and should be avoided, especially considering the characteristics of the stack sample environment.

The following guidelines should be employed in an optimum working environmental only. Extreme temperatures, sun exposure, chemical exposures, and other working environment hazards that add to physical and mental stress should be taken into consideration in the planning stages of each project.

- No more than 8 hours should be worked without a minimum of a 30-minute break.
- No more than 12 hours should be worked without a minimum of two 30-minute breaks.
- The maximum number of hours that should be worked in any 24-hour period of time is 16 hours, including travel time.
- The maximum number of hours that should be worked in any 48-hour period of time is 30 hours, including travel time.
- The maximum number of hours that should be worked in any 72-hour period of time is 44 hours, including travel time.
- The maximum number of hours that should be worked in any 96-hour period of time is 58 hours, including travel time.
- The maximum number of hours that should be worked in any 120-hour period of time is 72 hours, including travel time.
- The maximum number of hours that should be worked in any 168-hour period of time (one 7-day period) is 90 hours, including travel time.

Monorail Safety

MONORAIL SUPPORT SYSTEM
CIRCULAR STACKS



BASIC COMPONENTS

The basic components of a monorail support system are illustrated above for a circular stack. The support system would be the same for a rectangular stack, except that there would be more ports and they would be located only on one side of the duct. The complete system allows the sampling train to be moved back and forth so as to traverse the stack cross section during sampling. Systems are available from commercial suppliers of stack sampling equipment, and can also be fabricated from locally obtainable materials. The rail is usually made of steel or aluminum with a box or “T”cross section which provides a track for the trolley.

Unistrut or similar type rails are commonly used. The outer end support may be rigid, or a flexible line or cable. The industrial source personnel will have to provide an anchor to attach the outer end support. The anchor is usually provided in the form of an eyebolt or other bracket which is welded onto the stack. Other configurations are possible, some with support from underneath. An often overlooked part of the system is a safety line which will prevent the system from falling should any of the components fail.

Basic Safety Considerations

The primary safety concern with the monorail system is the hazard to personnel below should any of the support members fail. If the sampling platform extends out beyond the full length of the monorails, the equipment will fall only to the platform, creating a localized hazard. It is more common that the sampling platform provides only enough room for personnel to access the ports. In this scenario, the monorail and supported sampling equipment extends out over the platform, creating a hazard to personnel below.

Typical stack sampling equipment is designed with the sample collection equipment attached to a control console with a flexible umbilical cord. The umbilical cord contains various electrical and plastic tubing components. In many instances, it is not practical for the control console and operating personnel to be on the stack platform with the sample collection equipment. The location of the control personnel is limited by the length of the umbilical cord, and this often places them directly below the monorail and sample collection equipment. Whenever possible, this scenario should be avoided by the use of additional lengths of umbilical cord. While it may be necessary for the control personnel to be below the sample collection equipment, every effort should be made to locate outside the area directly below the equipment. In some test locations, the sample control personnel may be below the monorail at some intermediate location, and not at ground level where other personnel may be present. The area below the equipment should be marked with caution tape for the safety of other personnel not engaged in or aware of the sampling program. The industrial source personnel should be made aware of this hazard at the onset of the sampling program. Hard hats are imperative for anyone working below the sampling platform.

Design and Strength Considerations

Under normal circumstances, the monorail system load is about fifty pounds. Rarely would it exceed one hundred pounds. Most of the materials commonly used for construction are designed

for higher loads that this. However, if one or more parts of the system fails, the force of impact on the remaining components will be much greater. The monorail support system should be used to support only the sampling equipment for which it was designed. Failure is most likely where the various components fit together, or where they attach to the various anchor points.

The rail itself may be made of steel or aluminum. A perforated steel rail is available to save weight without sacrificing much strength. In lengths beyond approximately seven feet, an aluminum rail will tend to flex under load, and will need additional support. A long rail may be supported in the center as well as at the outside end to prevent flexing. It could also be made stronger by welding a piece of angle along its upper length. For circular stacks, using four test ports instead of two will allow the monorail to be shorter and stronger. This approach should be used when the stack diameter exceeds ten feet. Additional ports will add time to the test program, as the sampling will have to cease more often for port changes. This also requires a stack platform extending completely around the stack.

The design of the stack end support for the monorail varies widely. The test port is usually a three to six inch pipe nipple or coupling. Many stack end supports are designed to clamp onto the test port. These type systems offer the advantage of maintaining the proper distance above the test port with little work required of the industrial source personnel before the test crew arrives. Other types of stack end supports are welded to the stack at the proper height above the test port. A piece of angle iron or box channel must be welded at the correct height to center the probe in the test port. The welded support is by far the strongest design. The disadvantage is that the location requirement of the support may vary between different types of sampling equipment. For either type of stack support, there should be a positive means of attaching the monorail to the support. A bolt or pin should be installed to prevent the monorail from coming loose if an outward force is exerted.

The outer end support is typically a flexible steel cable, chain, rope, or strap that must be attached to the stack or other overhead member. A rigid support may be used, but is difficult to adapt from one job to the next. The outer end and stack end supports should be totally independent so that one may provide some degree of protection if the other fails. The flexible line must be attached to the monorail and the stack (or other anchor point) in a positive manner that will remain secure in the event that the stack end support fails. This requires the use of a connector with a closing gate, such as a snap link or carabiner, as opposed to an open “S” hook. If wire chain (crimped, not welded links) is used, connectors should always be placed so that they do not place a direct load on the crimp, only on the uncrimped surface. Care must be taken with synthetic rope or straps, as hot surfaces may cause them to weaken or melt.

Some sort of mechanism for taking up the slack from a flexible line must be incorporated in order to level the monorail. The mechanism should have a secure means of locking the line into place once the proper tension is achieved. Nylon rope or straps may stretch under load, so the system should be designed to be easily adjustable after installation. To attach the support to the stack, an eyebolt of sufficient strength should be welded to the stack at the proper height. The height of attachment should be chosen such that the angle that the monorail makes with the outside support line is no less than thirty degrees. Lower angles will place too much stress on the outside support line, and will make it difficult to level the monorail.

Special consideration must be given to stacks that cannot support the weight of the loaded monorail system. Examples are thin sheet metal ducts or ducts made of plastic or fiberglass. The monorail system may have to be supported from underneath at the stack end. A vertical steel member mounted next to the stack may be used to support the weight of the monorail. The steel member should be firmly anchored at its base. If possible, the support member should extend upward to an overhead structural member for a firm anchor. If this is possible, it may be used to provide an anchor for the outer end support as well. Otherwise, it may be possible to secure the steel member against the stack to prevent lateral movement, or it may be supported at the upper side(s) with additional members or cable. The outer end support may be supported from underneath in a similar manner. An overhead structural member will provide a safer support for the outside end.

The trolley design will be dictated primarily by the monorail design - the two must be compatible.

However, trolleys made by one manufacturer may work with monorails from a different manufacturer. There may be some slight differences in dimensions of the components from different manufacturers, so care must be taken that the trolley operates smoothly, and does not pull out of the monorail track under load. In the case of the box channel design, the area that retains the trolley must not be too wide to allow the trolley to slip through. This are should be inspected frequently, even with components from the same manufacturer, as the clearances may change with use.

Trolleys may have a single or double roller mechanism. The double roller design is safer as one set of rollers may support the system if the other fails. The sampling equipment is usually attached to the trolley by means of an eyebolt that is incorporated into the trolley frame. The means that some manufacturers secure the eyebolt to the frame is by crimping the shaft of the

bolt so that it will not pass through the hole in the frame. This should be inspected frequently, as the crimped surface will wear over time, and allow the bolt to separate from the trolley. A more secure system can be achieved by removing the crimped bolt, and replacing it with a threaded bolt. The threaded bolt can be retained in the trolley with a flat washer, castle nut and cotter pin. The eyebolt may be welded in place in the trolley frame, but then it would not pivot, and the rigid bolt would be more prone to breakage. The ability of the bolt to pivot is a very practical design feature, making the attachment and overall handling of the sampling equipment easier than a rigid system.

The sampling equipment should be attached to the trolley eyebolt with a carabiner, snaplink, or other connector with a closing gate. Open hooks make it easy to attach the equipment to the trolley, but also make it easy for the two to separate. Positive stops should be installed in both ends of the monorail so that the trolley will not pass out the ends. A bolt secured with a nut will suffice. The rail will then hold at least some of the equipment if one of the support ends fails.

A safety line should be attached to the sampling equipment while it is supported on the monorail system. All components of this system should be completely independent of the monorail system. A flexible cable, nylon rope, or nylon strap work well for this application. This system must be designed to support the weight of impact from the falling equipment. The safety line must be long enough to allow the sampling equipment to traverse the stack, but should employ little slack beyond this requirement. Ideally, the line should be anchored at a central location above the test ports. This will allow the safety line to remain fastened at all times, even when moving the equipment from one port to another. The central, overhead anchor point will also keep the safety line out of the way. This is not always practical, however, and separate anchor points for different test ports may be necessary. Even a lower anchor point, such as the safety railing on the sampling platform, will prevent some of the equipment from falling. As with the other components of the monorail system, connections should be made with carabiners, snaplinks, or other connectors with closing gates.

The installation and removal of the monorail support system should be performed by at least two crew members, and when the sampling platform is not cluttered with sampling equipment. Hard hats should be worn for this operation. Gloves may also be necessary for working around hot stack surfaces. The attachment and removal of the outer end support line to the stack is usually the most hazardous portion of installation. This anchor point will be difficult to reach as its height is usually eight to ten feet above the sampling platform. The safest way to make this attachment is to have the industrial source contact install a permanent cable or chain to the anchor point when it is attached to the stack. The chain or cable should be about half the

required length for the monorail support so that the tester may install a line that will allow the proper tension adjustment. The permanently attached line will thus hang down to a conveniently reached height for attachment and removal of the outer end support line.

Another safe alternative to make this attachment is by using a pole designed to hold and release the connector at the desired height A telescoping tent pole with the connector loosely attached with duct tape works well in a pinch. The tape will pull loose once the connector is secured to the stack. Note that removing the connector by this means is more difficult without a properly designed tool. The most hazardous approach to making this connection is to use a ladder or footstool. Sample boxes, coolers, buckets or other unstable platforms should not be used as a footstool. If it is necessary to use a ladder or stepladder to reach this connection point, a full body safety harness should be worn for fall protection.

The stack end support should be securely attached to the test port if this design is employed. The outer end support line is attached to the monorail with the trolley already inserted in the track. The rail is lifted into position, and the stack end attached to its support bracket. If the monorail is long and the sampling platform narrow, a body harness should be worn while lifting the monorail into place. A bolt or retaining pin should be placed in the monorail to securely fasten it to the stack support. With all components in place, the tension on the outer end support line should be adjusted to level the monorail. The system should be checked by applying weight to the rail to approximate the weight of the sampling equipment. The safety line should be attached to the anchor point.

Hanging and removing the sampling equipment on the monorail may be a one or two man job, depending on the weight and configuration of the equipment. Long probes will need to be supported by a second crew member while the sample box is lifted into place. If possible, the safety line should be attached to the sample box before it is lifted up to the monorail. If not, the safety line should be attached as soon as practical. The umbilical cord should be supported by something other than just the monorail, with enough slack to allow the full stack traverse. This will keep the full weight of the umbilical off of the monorail system with less strain on the electrical and tubing connections at the sample box. A short sling hung from the monorail near the stack end will support the probe and prevent it from swinging when not in the test port.

Moving the sampling equipment from one port to the next employs much the same technique as placing it on the monorail for the first time. Note that the sample box will probably be heavier

as ice and water will have been added for sampling. An additional crew member may be required to manage the umbilical cord if it is in a particularly cumbersome location.

The complete monorail support system should be inspected prior to each use. The rails should be free of bends, corrosion, or obvious signs of fatigue . The slot that the trolley passes through should be uniform and the correct width to retain the trolley under load. The attachment points for the stack and outside end supports should be free from defects. The trolleys should be inspected to insure that the eyebolt is securely anchored in the frame. The wheels should likewise be secure in the frame, and rotate freely. The outside end support line should be checked for any signs of deterioration. Steel cable and chain should be inspected for corrosion, kinks, and any other sign of weakness. Ropes and cables should be checked for fraying. The attachment connections at each end should be secure. The attachment connections on nylon or other synthetic straps are usually sewn into a loop of material, and the stitching should be inspected for signs of wear or deterioration. Synthetic materials are prone to damage from extended sun exposure, so should be retired over a reasonable interval. This is especially true if they are left in place over extended periods, and become faded in appearance. The tension adjustment mechanism should be inspected for smooth operation, and that it locks the line firmly in place as required.

The monorail support system and sampling equipment are often put in place a day before sampling commences. They also are left in place for long periods with extended sampling programs on the same stack. In these instances, care should be taken that all is secure before leaving the job site. Ideally, the equipment should be removed from the monorail and secured to the sampling platform when left unattended. If this is not practical, then it should be secured as close to the stack as possible, and the probe should be tied off separately to prevent it from swinging. When covered with tarps for rain protection, the sampling equipment should be wrapped tightly to minimize the surface area that the wind may catch. The safety line should always be attached when the equipment is left unattended, and should be adjusted so that minimal slack is present.

Preparation of the sampling platform for testing will usually be performed by the industrial source contact prior to the test crew arriving on site , and delays in the test program result if the placement is incorrect. The best way to set up the proper preparations is with a site visit prior to the test date. If not feasible, precise instructions on the preparation must be given to the contact through phone conversations, or preferably with sketches provided by mail or FAX. It is very helpful if the source contact can provide the tester with photographs of the sampling

location. The critical information to provide the source contact are the heights of the stack support bracket and upper end support anchor over the test port. The dimensions of a sampling corridor extending out from each test port should be specified. The sampling corridor must be free of obstructions that would prevent the traversing of the stack. If the test ports are not high enough, the sampling platform safety railing will obstruct the sampling corridor. If possible, relocating the test ports will alleviate this problem. Another alternative is to cut out the section of railing that obstructs the corridor. A chain should be attached across the opening, and secured in place whenever the sampling equipment is not in place or obstructed during sampling. After the test program is completed, the rail may be welded back in place. Sources that require frequent testing may opt to put a hinge on the rail so that it may be easily moved out of the way, and put back in place after each test project is completed.

Personal Protective Equipment

INTRODUCTION

Personal protective equipment (PPE) general requirements are regulated under OSHA rules published in Code of Federal Regulations 29 CFR 1910.132. Respiratory protection rules are published in 29 CFR 1910.134. Personal protective equipment that a stack sampler is likely to use includes chemical resistant gloves, safety shoes, chemical resistant boots, hard hats, ear plugs, safety glasses, splash goggles, face shields, chemical barrier suits and respirators. Briefly, PPE must be provided to the employee and kept in reliable and sanitary condition so it can prevent injury or impairment in the function of any part of the body through adsorption, inhalation, or physical contact. PPE use and care of equipment is ultimately the responsibility of the user. All PPE should be regularly inspected. At a minimum, the PPE must be inspected prior to use and repaired and replaced as necessary.

The use of respiratory protection devices (respirators) require training and medical checks to determine if the employee can safely use the devices selected. If sampling is anticipated in locations where PPE is recommended or required, applicable training to affected employees must be provided on a regular basis. The trained employee shall know at least the following:

- When PPE is necessary
- What PPE is necessary
- How to properly don, duff, adjust, and wear the PPE
- The limitations of the PPE
- The proper care, maintenance, cleaning, useful life, and disposal of the PPE

ASSESSMENT GUIDELINES

At your pre-test survey meeting with the source owner, identify what hazards are likely to occur at or near each source being sampled. Request to have the facility safety officer attend this meeting. Review the Safety Guidelines for Pre-test Meeting and Chemical Exposure. Conduct a walk-through survey in the areas where sampling will be conducted and the access routes to and from the source sites. Consideration should be given to the basic hazard categories:

- Impact
- Penetration
- Compression (roll over)
- Chemical
- Heat
- Harmful dust
- Light (optical) radiation

GENERAL GUIDELINES

Where possible, engineering controls should be used to eliminate hazards. For example, sharp points and edges should be removed or covered with barriers that will prevent injury. If arc welding is within view of the sampling site, erect a tarp or other barrier to block the radiation. Rope off areas where there is risk of falling objects. Post signs to keep people out of these areas. Use suitable hearing protection in areas where noise exceeds safe levels. Review other sections of this handbook covering Chemical Exposure (Section 4), Heat Deflectors (Hot Stacks) (TBD) and Ambient Temperature (Section 2). There is a good discussion on levels of protection and protective gear in 29 CFR 1910.120, Appendix B. The source owner may require that the sampling team attend an in-house safety-training program for contractors. Check on this before the sampling team arrives on-site to avoid scheduling problems.

Personal protective equipment that a stack sampler is likely to use includes chemical resistant gloves, safety shoes, chemical resistant boots, hard hats, ear plugs, safety glasses, splash goggles, face shields, chemical barrier suits, and respirators.

The hazards that most frequently confront stack samplers are chemicals and harmful dust that are inhaled or adsorbed through the skin. Gloves, chemical resistant suits, boots and respirators must be selected that are suitable for use with the materials identified in the sampling environment. Consult glove and barrier suit manufacturers application data to select the best materials of construction to prevent skin contact from hazardous materials.

RESPIRATOR SELECTION

Respirator selection requires detailed knowledge of the sampling location in order to select the appropriate respirator.

Airborne chemicals are often invisible and may not offer adequate odor to warn of trouble (warning properties). Rely on air sampling data or engineering estimates to select respirators. Respirators have two types of function: air-purifying and air-supplying. Air-purifying respirators have half-face or full-face masks with filters or adsorption cartridges that remove the contaminants from the air. Air supplying respirators provide clean air with positive pressure to a full-face mask. The supplied air may be from a compressed air tank worn on the back (self-contained breathing apparatus, SCBA) or from an air hose (umbilical style) connected to compressed tanks or a compressor. Use of SCBA requires training prior to use.

All respirator users must be fit tested with the respirator make and model to be used. The full-face masks offer both face and eye protection. Corrective lenses can be mounted inside a full-face mask. OSHA rules prohibit facial hair under the mask's seal on the face. See 29 CFR 1910.134 or consult an industrial hygienist for fit testing details.

Air-supplying respirators are required if the sampling location has:

1. Unidentified airborne materials
2. A complex mix of materials
3 Contaminants that are over 50 times the Threshold Limit Value (TLV)
4. Suffocating gases
5. Less than 19.5 % oxygen
6. An atmosphere immediately dangerous to life and health (IDLH)

SCBA contain enough air for 30 minutes, more or less, depending on employee size and difficulty of the work. Umbilical style air-supplied respirators offer longer service without the air tank changes required with SCBA.

When the sampling area has identified airborne contaminants, that are less than 10 times the TLV, a half-mask air-purifying respirator may be used. A full-face air-purifying respirator may be used in atmospheres up to 50 times the TLV. Filters and adsorption cartridges, for air-purifying respirators, must be selected for the compounds that they are specifically designed to remove. Combination cartridges are available that remove two or more classes of compounds. Many cartridges have indicators that warn when the cartridge needs to be changed. If they do not have indicators, the cartridges must be changed on a timed schedule that will not allow contaminant break-through resulting in over exposure.

Airborne chemicals can be present in the following physical/chemical forms: gases, vapors, dusts, fumes, and mists. Understanding the nature and physical form of the air contaminants is essential in the selection of air-purifying cartridges. Each form is defined below.

Gases: A material that does not condense at room temperature. Examples are carbon monoxide and nitrogen.

Vapors: Liquid or solid materials at room temperature that evaporate to the vapor phase, such as toluene vapor.

Dusts: Particulate matter that is airborne. In high concentrations the dust is visible. A strong light beam or sunlight will cause the particles to sparkle (Tyndall effect).

Fumes: Vapors usually generated by heat that have condensed to form a very small airborne particulate. Examples are welding fumes or maleic anhydride fumes.

Mists: Small airborne droplets of liquid that form a visible cloud in a light beam (Tyndall effect).

Chemical dusts, fumes and mists require a high efficiency filter and a back-up adsorption cartridge to remove vapors. The high efficiency filter is adequate for non-volatile dusts such as concrete dust. Paint over-spray requires a deep bed filter to entrain the mist and particulate and a carbon cartridge to adsorb solvent vapors. Most organic vapors will be removed with a carbon cartridge. Combination cartridges are available to remove acid gases and organic vapors. The cartridges are color coded according to the class of compounds they will remove. A partial list of cartridge color codes and compounds they remove is listed below.

Cartridge Color	*Compounds Removed*
Black	Organic vapors
Yellow	Organic vapors, acid gases and low conc. chlorine
White	Acid gases
Green	Ammonia and amines
Magenta (red) *	High efficiency filter for particulates, fumes or mists

*May require a back-up adsorption cartridge

Consult the manufacturer's application data to select the appropriate cartridges.

EYE PROTECTION

Eye protection should be worn at all times while on a site. The availability of lightweight and stylish safety glasses (both sunglasses and clear) provide the test personnel with a wide selection and no excuse not to wear eye protection. Glasses with side shields should be required. Additionally, if working in some areas where hazards are greater than normal (i.e., working with chemicals, grinding, welding), face shields should be worn. All safety glasses must have a "Z87" notation on the inside of the earpiece, near the glasses. This notation certifies the glasses meet the requirements of OSHA.

SAFETY SHOES

Safety shoes should be worn at all times while on a test site. Safety shoes protect feet and especially toes against falling objects, but also against chemical spills. For this reason, leather tops, not porous sport shoes, should be worn. Additionally, due to the stack tester being on

his/her feet most of the day and walking distances around a facility, care should be taken to provide comfortable shoes/boots with maximum support.

HEARING PROTECTION

Hearing protection should be worn where there is a potential for sharp sound impacts or constant high decibel levels throughout a work period. The long-term effect of the constant high decibel levels will increase the hearing loss just as much as the sharp sound impacts. Most facilities will post areas of required wearing of hearing protection. Do not depend solely on those postings. Test crew leaders and individuals should be cognizant of high noise areas, protecting themselves by using their knowledge and experience. Ear plugs as well as ear muffs should be available for use.

HAND PROTECTION

Hand protection consists of gloves that are used in certain instances during test campaigns. Commonly, leather gloves for standard test operations should be used by the stack tester. This will protect against abrasions, cuts, some burns, and some chemical contact. These are not sufficient protection against chemical contact and adsorption when working with sources that are high moisture and have harmful chemical constituents. In such cases, latex or compatible glove hand protection should be worn. This also is the case for the sample preparation and sample recovery personnel who work with various chemicals in preparing the sample train glassware. Consult the glove manufacturer's literature to assure the glove you use is correct for your situation.

Another often overlooked area for hand protection is in the case of the technician back in the office who disassembles the glassware for decontamination prior to the next sampling project. Disassembly of ground glass joints can be dangerous. All personnel working with the glassware should wear protective gloves that will guard against broken glass penetrating the skin. Many technicians and lab personnel have been injured by twisting and over-stressing the glass joints to the point where a piece of sharp glass severely injures the hand.

HARD HATS

A hard hat should be worn during all test campaigns where there is any potential for falling objects from overhead. Additionally, the use of a hard hat should be required where there is a

potential for hitting the head against low lying structural beams or equipment. Hard hats should be non-conductive to electricity, and should be inspected and cleaned regularly. The headband insert should be included in the inspection. Any defect should be cause to dispose of the hat and issue another. Hard hat manufacturers, as well as OSHA, forbid any alteration to a hard hat, which includes wearing the hat backward, painting, cutting, or drilling of the hat. Hard hats have an expiration data on the underside of the bill of the hat. These expiration dates, as well as OSHA certification notations, should be followed when choosing a hard hat.

SKIN PROTECTION

Many source owners have requirements for either long sleeve shirts or a fire retardant “Nomex” coverall for personnel working on their site. It is advisable to provide the stack tester with appropriate clothing on sites. Obviously, shorts and tank tops should never be work on a test site. The need for protection from abrasions, sunburn, radiant heat and cuts is paramount. Many times cotton materials, such as denim jeans, are not safe due to their inherent flammability and absorptive qualities for liquids, both moisture and chemical.

HYGIENE

Good personal hygiene practices should be followed. Most facial hair is not allowed when the use of respiratory protection may be required. Long hair can be a hazard to personnel. Insure that the longer hair is pulled back and tied in order to prevent against any entanglement with moving equipment or burning when near high heat sources or sparks.

Platform Areas

PLATFORM AND SCAFFOLDING WORK AREAS

1.1 Work Platforms

This section discusses work platform safety such as how to protect areas below work platforms, the flooring of work platforms, toeboards, tools and guard railings.

1.1.1 Protecting Areas Below Work Platforms

Areas in the "impact zone" below sampling operations and hoisting operations should be roped off or barricaded to keep personnel out of the area where parts or equipment may fall.

1.1.2 Flooring of Work Platforms

Open-grating platforms used for stack sampling may be floored with plywood to prevent small tools and parts from falling through the grating. If solid flooring and toeboards cannot be provided, tool belts and other devices should be used to prevent material from falling from sampling areas. To minimize tripping hazards in elevated locations, the flooring should be flat and level, and taped. Tools and small objects should be stored so that they do not clutter the work platform. Tripping hazards that cannot be eliminated should be minimized and marked to reduce their danger.

1.1.3 Toeboards

Toeboards must be provided as curbs around the edges of working platforms to prevent equipment, small tools, and other gear from being pushed or kicked over the edge. Toeboards are not required if nothing in use can be dropped or if no one can walk under the platform or close enough to the “impact zone” to be hurt.

Toeboards must be three and one-half inches in height from the top edge of the toeboard to the top of the working surface. Lumber that is nominal 1 x 4 inches or 2 x 4 inches is acceptable for toeboards.

1.1.4 Tools

It is important to prevent tools and other work materials from falling off elevated work platforms to ensure safety and uninterrupted work. Although toeboards and solid flooring will help, other measures may be needed.

If tools or other equipment are used beyond the edge of the working platform, it is advisable to take special precautions to prevent them from falling. In some situations, it may be desirable to tie tools to the platform or another superstructure. For example, a tie line should be attached to any wrench used to loosen a tight plug in a sampling port. This will prevent the wrench from slipping and falling.

1.1.5 Protection Against Falls from Heights

Working platforms are usually built with standard guard railings, but roofs and temporary working surfaces seldom have any sort of railing. This section describes the standards for permanent and temporary guard railings, where railings are needed, and situations where safety lines may be needed .

Working platforms and elevated walkways should have guard railings high enough to prevent workers from falling off the elevated surfaces. If you find that the height of a guard railing is below your waist level or center of gravity, you should use extra caution while working on the platform.

If you find that you have to work on a platform that does not have a guard railing, you should install a temporary railing or use some other method to protect yourself, such as a safety belt and/or a shock-absorbing lifeline tied to the structure.

Standards for Guard Railings: Usually standard guard railings are required for all walking and working surfaces that are four feet or more above another level. Standard guard railings have a top rail that is 42 inches above the working surface, and a midrail that is about 21 inches above the working surface. (Midrails are intended to prevent workers from falling under the guard railings.)

To provide reliable protection, guard railings should be able to withstand a 200-pound force applied in any direction at any point on the top rail. If a guard railing appears too weak to

support you if you fall against it, strengthen, supplement, or replace the railing before you begin work on the platform or scaffold. When testing a railing, be careful not to fall if the railing fails.

Openings in Guard Railings: If sections of an existing guard railing must be removed to gain access to sampling ports for long probes, there should be some alternative guarding of the opening in the railing. One alternative would be a temporary railing above and below the path of the sampling train.

Another alternative would be a railing that projects out beyond the opening providing protection against falls. If you encounter an unprotected opening in a guard railing, protect yourself by making a temporary railing with rope, chain, or other material. If guard railings have openings for hoisting, stairs, or ladders that are near areas used for sampling operations, try to close the openings with a snap chain, rope or other temporary barrier .

Because sampling operations must often be performed in locations not designed for work protection, existing railings may need to be augmented and temporary protection of openings may need to be added to prevent falls.

Temporary Guard Railings: When there is frequent need to walk or work near the unprotected edge of roof or other elevated surfaces, a temporary guard railing can be installed to prevent falls. Such a railing can be provided by tightly strung rope or cable at 21 and 42 inches above the surface. If rope or cable is used as a temporary guard railing, the rope or cable should have less than 6 inches of sway under a 200-pound force and sag no more than 3 inches between supports. Strong vertical supports should be installed (safely) at intervals that do not exceed 8 feet, so that the rope or cable can provide reliable support protection.

On some high surfaces it may be desirable to provide a temporary guard railing or rope even if sampling personnel do not plan to work near the edge. If the surface slope is rough or slippery, a safety guard railing or rope or a safety line should be used. In such hazardous situations, the 21-inch high midrail is particularly important to prevent someone from slipping or sliding under the 42-inch high rope or guard railing.

Alternatives to Guard Railings: Although guard railings are usually required for walking and working surfaces that are four feet or more above another level, there are some situations where the risk of falling does not seem to justify the expense and hazards of erecting a temporary railing. For example, consider a one-story flat roof where sampling operations are 12 feet or more from the edge. Although sampling personnel can walk over to the edge, they will usually be working far enough away that they would not be likely to fall from the roof.

Under some extreme conditions, where guard rails or guard ropes cannot be provided for the work area and where fall distances could cause serious injuries, personnel should wear safety harnesses connected to well-rigged safety lines. Safety harnesses that provide protection against falls are the type with loops around the shoulders, legs, and waist. Safety lines for fall interruption must be equipped with shock-absorbing devices to prevent serious or fatal injury from the impact of a sudden stop at the end of the rope.

1.2 Scaffolding Platforms

This section lists some important things to check before you begin working on scaffolding. This section also is intended to provide some specifications and recommendations if you are responsible for supervising scaffolding erection or contracting for it. Refer to OSHA 29 CFR 1910.28 for more detailed federal regulations affecting scaffolding.

1.2.1 Inspection of Scaffolding

Portable scaffolding should be erected so that it is secure enough to minimize horizontal movement and to prevent tipping over due to wind, load, or working stresses. Scaffolding over 20 feet high should be secured or tied off at a minimum for every 20 feet elevation. Working surfaces on scaffolding should be strong enough to support personnel and equipment. If the floor of the platform is built of boards or sheets of plywood, they should not slide or fall off of the supports. If the floor is built of planks that overlap, they should overlap at least 12 inches or be nailed down or secured against movement. It is important that all plywood and planking be secured against the wind which may move or lift them.

Before using a scaffolding platform, use this safety checklist for the condition of the scaffold:

- ❑ Does the scaffolding feel stable and firm?
- ❑ Are all connections made firm, either with pins, bolts or nested construction?
- ❑ Are there secure cross braces to prevent the scaffolding from tipping?
- ❑ Are the scaffolding platforms wide enough to allow work and safe testing ?
- ❑ Are the scaffolding platforms secured against tearing and being blown over by the wind?
- ❑ Do the scaffolding platforms have 42-inch high guard rails with midrails, or does the cross-bracing give equivalent protection?
- ❑ Do the scaffolding platforms have toeboards?
- ❑ Are the toeboards of sufficient height (3.5 inches or more) to prevent tools and . equipment from falling?
- ❑ Is there an access ladder that is either built in and continuous, or is there a temporary ladder lashed firmly?
- ❑ Are barricades or signs present to prevent the scaffold from being struck by vehicles and moving traffic?

1.2.2 Erection of Scaffolding

Scaffolding should be cross braced and erected on solid footing of sufficient size to avoid sinking into the ground or into the roof. Cross braces serve the important function of keeping the scaffolding erect by preventing it from tipping over or collapsing. Most sections of scaffolding should have the cross braces connected, and the connections should be secured to keep the braces in place.

Scaffolding should be erected so that vertical sections are at right angles to each other to provide a rectangular area for the platform and greater strength.

Scaffolding with built-in ladder sections should be erected so that all the ladder sections are in a straight run. This will facilitate use of the ladder and prevent injuries which may occur if personnel are unaware of or forget about shifts in the position of ladder sections. If the scaffolding is erected where it may be struck by vehicles, barricades and signs should be installed.

If you are responsible for erection of scaffolding, use the requirements discussed in this section as part of the specifications. The checklist can also be used as informal safety information for anyone who may erect scaffolding that personnel may have to use. Additional safety requirements regarding scaffolding include the following:

- Scaffolding should be erected in accordance with these guidelines for persons engaged in work that cannot be performed safely from the ground.
- The anchorage for scaffolding must be sound and capable of carrying the maximum intended weight. Unstable objects must not be used to support scaffolding.
- For wood scaffolding platforms, guard rails should all be at least 2 x 4 inches, installed at a minimum of 36 inches or at a maximum of 42 inches high; with a midrail, when required, of at least 1 x 4-inch lumber. Supports should be at intervals not to exceed 10 feet. Toeboards must be a minimum of 4 inches in height.
- Scaffolding must be capable of supporting 4 times the maximum intended load.
- Scaffolding must not be altered or moved horizontally while it is in use or occupied.
- Any scaffolding damaged or weakened must be immediately repaired and must not be used until repairs have been completed.
- Scaffolding must not be loaded in excess of the working load for which it is intended.

PLATFORM SAFETY

Simply put, climbing to and being on existing platforms can be dangerous. OSHA stipulates that platforms must be maintained in a condition that is equal to their original design specifications. Assuming the platform was constructed properly by a professional structural engineering firm and has been maintained in good working condition, it should be safe to support people and equipment. A wonderful SES member lost his life assuming his company's platform was safe - assumption is not good enough!

At a minimum, the egress and platform should be verified safe by plant personnel prior to any contractor using it. If weaknesses have been identified (grating, rails, ladders, etc.) then the testing crew should not test until the platform, etc. is deemed safe. SES believes that a checklist should be used identifying potential problems for the testing team and acknowledged by the plant personnel responsible for maintaining the platform.

1. When was the platform last inspected by plant personnel?
2. Has rust (flooring, rails, fasteners, etc.) been noticed and replacement parts identified?
3. Is guardrail height and stability good?
4. Does the platform have kick boards/plates to prevent items from falling?
5. Has square footage weight limits for equipment and people been specified?
6. Have tripping hazards been identified?
7. Are ports of sufficient height above grating to permit sampling train clearance? (not too high requiring a ladder, etc.)
8. Are monorail stack fasteners such as eyebolts, angle iron, etc. of sufficient strength to support sample train load vectors by a factor of 4? Have the monorails been stabilized?
9. Is the sampling team protected from hot stack surfaces, positive stack leakage and exit stack gas down wash?
10, If handrails must be cut (last option) to accommodate traversing sampling equipment, are chains or tubing available to eliminate tester falling through opening?

11. Can the handrails support equipment lifting gantry and pulley system? What is the maximum lifting load? Is the load above the handrail to permit load swing into platform area?
12. Are electrical outlets ground fault protected?
13. Is there proper lighting in the event of darkness?
14. Is the point of ingress/egress onto and off of the platform safe?
15. Is the platform lightning protected?
16. Can the area below the platform be caution taped (barricaded) to prevent falling objects from injuring personnel below?
17. Can equipment be safely tied down in the event of foul weather?
18. Is communication between ground and platform in place? Who provides?
19. Can the test team safely evacuate the platform in an emergency situation?
20. Is there more than one (1) escape route?
21. Are respirators required for escape purposes?
22. Are respirators required during testing?
23. Are there plans for worker injury evaluation?
24. Are testing personnel trained in first aid?
25. Does the plant provide emergency responders?
26. Is worker fall protection platform hook-ups available in the event safety harnesses are a necessity?
27. Is there safe clearance between platform and power lines (10 – 45 feet) depending on power line voltage – phase to phase (KV)?
28. Are equipment grounding straps available in case of static electricity?
29. Will the platform working area be safe in adverse weather such as rain, snow or sleet?
30. Are portable enclosures permitted on the platform?
31. Are portable heaters (propane or electric) permitted on the platform?
32. Has the plant emergency system/alarms been explained?
33. If evacuation occurs, is the egress route safe from hazards?
34. Are there any other constituents such as steam plumes, stack gases, etc. that could enter the platform area?

Please have a safe testing experience. The platform must be in good working condition. Look out for yourself and your team. Don't assume it is safe. Check it out.

Additionally, Good Housekeeping on the platform is important. Secure all electrical cables and tape down as appropriate to minimize tripping.

All tools, etc. should be placed in a container when not in use and secure the container as appropriate. Remove all unnecessary items (probes, coolers, garbage, extension cords, consoles, pumps, etc.) from the platform. Place all garbage in containers or plastic bags. Make sure all tarps are secure.

Positive Pressure Ducts and Stacks

Positive pressure ducts and stacks are any source where the internal pressure is greater than atmospheric. When the positive pressure produces a hazardous environment for the sampler, special precautions need to be taken. Many things can make a positive pressure duct hazardous:

- ***Temperature*** - the exiting gas can burn unprotected areas of the body;
- ***Toxic*** - the gas can contain a toxic gas or compound which, when inhaled or ingested, could cause harm;
- ***Asphyxiant*** - the gas could be such that the sampler could be asphyxiated;
- ***Flammable/explosive*** - the gas could have be flammable if released in the presence of a spark with oxygen;
- ***Steam*** - high pressure steam presents a combination of problems;
- ***Pressure*** - the pressure itself can be a problem if great enough.

It is obvious that the tester should know what is in the duct prior to sampling. All pre-surveys and engineering checks should ask what the pressure, temperature, constituents and toxic levels are in the ducts to be sampled. Most plant engineers will readily volunteer this information. Occasionally it is unknown. In these instances, take the most stringent precautions prior to sampling.

1. HIGH TEMPERATURE

The specific hazard of a positive pressure duct or stack containing high temperature gases is the possibility of burns. The hazards increase rapidly with the increase of either the temperature or pressure or both.

Appropriate precautions should be taken before you first open the test port.

CONTROL MEASURES

Personal Protective Equipment for High Temperatures

High temperature gloves

High temperature gloves and face shield,

High temperature gloves, face shield, and fire resistant jacket,

Face shield, heat reflective jacket, gloves, and pants.

NOTE: Please read the chapter on ambient temperatures to familiarize yourself on high ambient temperatures and the limits for heat exhaustion.

2. TOXIC GASES

The combination of positive pressure gas streams and gases containing toxic components dictates the use of appropriate PPE. Often the concentration of toxic components in the gas stream exceeds the protective capabilities of standard filtration respirators. As with high temperature positive pressure situations, the hazard increases rapidly with the increase of either or both of the toxicity of the gas and the pressure of the gas stream.

Sources containing Carbon Monoxide and other colorless odorless toxic gases require the use of gas monitors with alarms to ensure that levels do not approach dangerous levels without warning.

Under particularly hazardous situations, the use of positive pressure air supplied breathing apparatus should be used in combination with double-sealed test ports.

Personal Protective Equipment for Toxic Gases

Half-faced respirator with appropriate cartridges

Full-faced respirator with appropriate cartridges

Positive pressure purified air-supplied respirator or SCBA

DOUBLE SEALED TEST PORTS

Double seals on test ports should be employed to allow insertion of test probes and forming a compression seal around the probe before opening the second seal into the stack or duct. The inner seal must consist of a gate or guillotine valve.

This equipment also requires a cylindrical over-sheath on the probe assembly with a matching compression fitting that can be attached to the port using a pipe thread or flange for sealing. A diagram of a typical arrangement is presented as Figure 1.

Double seals on test ports should be employed to allow insertion of test probes into a duct without opening the duct to the atmosphere and risking exposure of test personnel. This is done by partially inserting the probe into the port while the inner seal is still closed. After the probe is partially inserted a compression seal is made around the probe. Once the compression seal is made the gate valve is opened and the probe can be inserted into the gas stream. Extraction of the probe is accomplished in reverse order.

For particularly hazardous situations, a nitrogen or air purge of the insertion chamber should be initiated once the probe is installed but before the test port gate valve is opened. This is reversed for the removal of the probe.

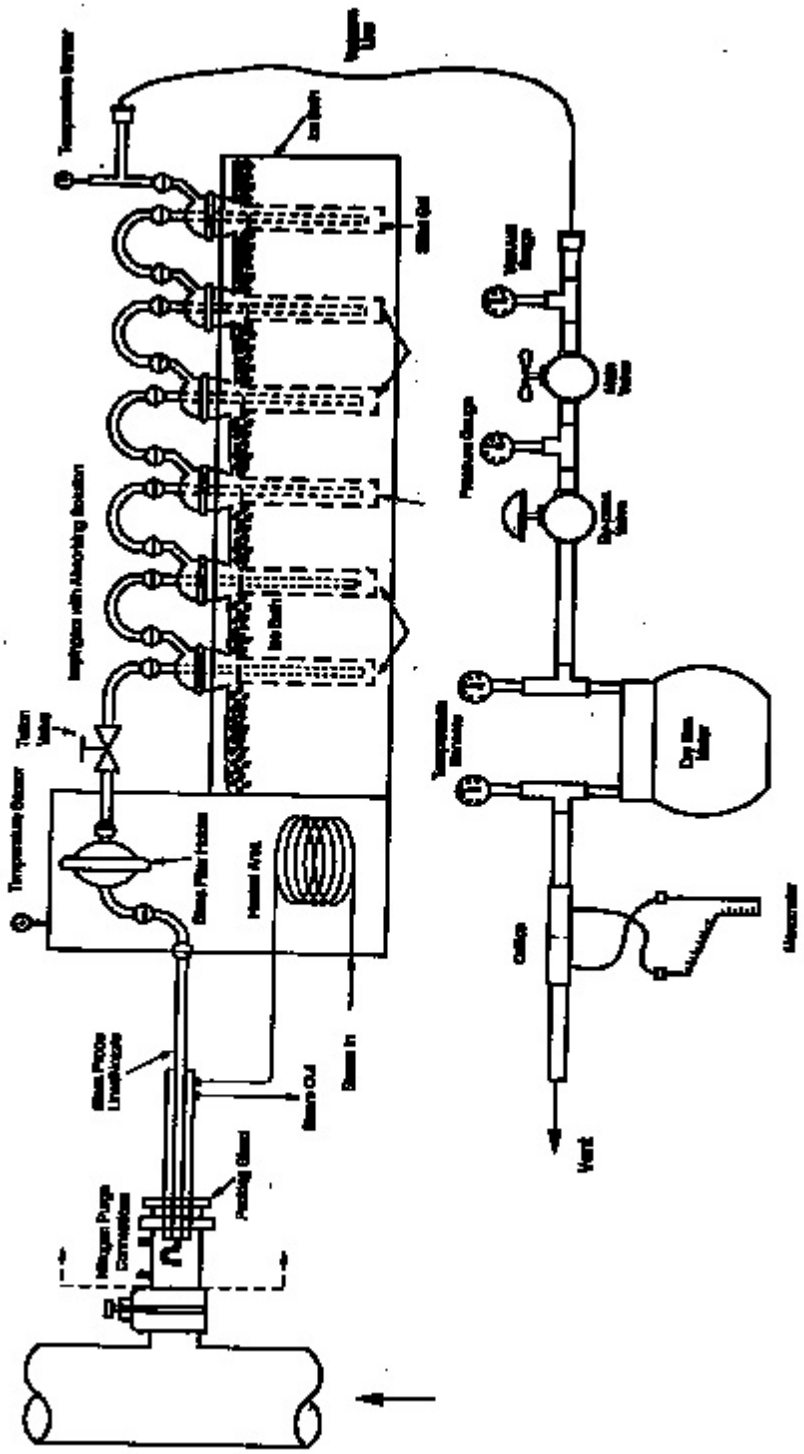
3. ASPHYXIANT

Some positive pressure stacks or ducts contain non-breathable air. These gaseous emissions can build up in an enclosed area to the point of becoming an asphyxiant. An example of this would be N_2, He, or CO_2. The excess of non-breathable gases can cause asphyxiation in a rather short time period.

NOTE: CO_2 is particularly hazardous as one breath of concentrated CO_2 will cause an involuntary collapse.

The first priority for these leaks would be to prevent the leaks by using the double sealed ports. A second would be to not allow the buildup of these gases by diluting with fresh breathable air. The third would be by use of supplied air in a respirator.

Figure 1. Positive Pressure
Explosive/Hazardous Atmosphere Sampling Train



4. FLAMMABLE GASES

Sampling flammable gases, whether positive pressure or not, presents a serious hazard to the sampler. The heaters in a probe or filter assembly will supply the needed ignition point to cause a leak to burn/explode. It is critical to contain the flammable gases and limit their exposure to air/sparks. Figure 1 indicates a train set up for sampling flammable gases. It heats both the probe and filter assembly with plant steam. Please note that plant steam leaks are a hazard themselves. Also note that special care must be taken to exhaust the measured gas to the proper place either returned to the duct/stack or vented in a safe manner.

Some flammable gases, *i.e.,* CO, are both flammable and toxic. Personal monitors should be used to indicate the toxic level of the gas as well as to indicate the flammable level. In most cases, the toxic level will be much lower than the explosive limit.

5. STEAM

Power plants and some chemical plants utilize high pressure steam. Even low pressure steam will cause severe burns. While we only occasionally sample these streams, the high pressure/low pressure steam is all around where we work. There are several hazards associated with the steam. Burns are the most common; inhalation of high pressure steam can be fatal. Pure steam can be an asphyxiant. A sudden steam release can be extremely loud.

The best defense for steam leaks is not to be in the area where the leaks occur. Note in your daily check list where leaks might occur and identify an egress plan. Note that most high pressure steam leaks are unplanned events.

If you must work around low pressure leaks, note that porous gloves/overalls will not protect the skin from burns. Also note that sufficient exposure to non-porous gloves and overalls will heat up the body with no means of cooling. Refer to the symptoms in the section on ambient heat.

6. PRESSURE

Sometimes the pressure itself can be a hazard even if the duct contains nothing hazardous. Any pressure greater than 15 psi can launch a probe like a rocket. Small leaks of high pressure can cut into the skin like a knife.

Once again, the value of a pre-survey and a project safety checklist is inherent. Leaks are not planned and staying away from them while reporting them to the proper department is advised.

The use of a dual-gated valve is advisable with high pressure situations. The sampling train needs to be coupled to the stack with a chain winch or “come-along” capable of holding the probe and train in place.

Pre-Test Survey Meeting

Safety Guideline for Stack Samplers

INTRODUCTION

The pre-test survey meeting with the source owner should include all of the people and information that are essential to make decisions and secure agreement from all parties on the source testing protocols. The meeting should clarify the expectations of the source owner, the stack samplers, and the applicable regulatory agencies. The pre-test survey meeting offers an opportunity to review information on safety and industrial hygiene at the facility, and investigate safety issues specific to the sources being tested. The stack samplers should work with the source owner to develop the agenda for the meeting, including a walk-through of all areas where the sampling team will be working.

GENERAL GUIDELINES

Review the SES Safety Guidelines prior to the pre-test survey meeting, and make notes on any safety issues that may be applicable at the facility to be tested. Include these items on the meeting agenda. Schedule the pre-test survey meeting early, with enough time to allow for any sampling protocol modifications or maintenance procedures (repairs) that may be identified in the meeting or during the walk-through.

The pre-test survey meeting participants will vary depending on the facility and the test methods to be conducted. The following list suggests who may be included in the meeting.

- Facility Representative
- Facility Source Test Coordinator
- Source Test Team Leader
- Facility Safety officer
- Facility Manufacturing Unit Representative
- Regulatory Agency Source Test Observer

The Source Test Team Leader or the Facility Source Test Coordinator may request that additional people attend the meeting to help resolve safety issues.

Many source owners will have a safety-training program in place that the stack samplers will be required to attend. Schedule this training so that it does not interfere with the sampling schedule. Review the in-house safety program and ask questions about any parts of the program that are not clear. If the safety-training program does not answer your questions, ask the representative to bring someone in who has additional knowledge and can answer your questions.

Ask for copies of the Material Safety Data Sheets (MSDS) for the materials you will most likely encounter. Read the MSDS before you arrive on- site. Know what the hazardous properties of the materials are and learn the symptoms of exposure. Understand the first aid and clean up recommendations before you arrive on site. Always try to work in pairs so there is someone available to assist if help is needed.

Facility walk-through

- Request to have the facility safety officer and the source test coordinator participate in the walk-through.

- Inspect the source locations to be sampled and the access to and from the testing sites. Ask questions about anything that may be a safety issue for the sampling crew. Also consider the safety risk that the sampling may have on other personnel at or near the test site.

- Make a list of modifications and repairs that need to be done prior to sampling. Review the list with the appropriate facility representatives before leaving the meeting. Establish accountabilities for each action item on the list. Plan to follow up on the action items before returning to conduct the source sampling.

- Determine who your plant contact is for emergencies and how to initiate emergency medical services.

- Identify the nearest locations of eye wash fountains and safety showers.

- Identify any unusual conditions requiring special equipment during the testing. For example: fall protection devices, fire extinguishers, GFCI, etc.

Roof Top Sampling

Concerns and OSHA Regulations

I. INTRODUCTION AND PHILOSOPHY

- 40 CFR 60.8 requires owners to provide safe sampling ports and safe access to the ports.

- Although 60.8 stipulates that the source owner is responsible for providing a safe working environment for source testing, source testing personnel are the ultimate victims of unsafe conditions.

- Safe working conditions are the goal in every company safety policy.

- Pre-test survey: The site must be surveyed for safety concerns before work begins: either during the pre-test site survey before the job is bid, or as the first task at the site when the test begins. During the survey all necessary actions will be identified and tasks allotted to the site personnel or test personnel.

- The test team members shall always be on the lookout for any unsafe conditions that were not dealt with in the pre-test survey. If any are identified, they must be dealt with.

- Many variables affect safety; what is safe one day may not be the next day. Variables such as weather and darkness can turn a safe situation into a life threat. Individual judgement must always be exercised.

II. WORKER CONCERNS

TOP 10 Concerns

I. Skylights must be lit from within at all times. Opaque corrugated fiberglass roof sections must be marked and cordoned off.

II. Source must provide fall restraint tie off points if it is a flat roof without side fall prevention, or any pitched roof.

III. For sheet metal roofs with questionable structural integrity (i.e. pinholes of light coming through, rusting, sagging, evidence of fire) working platforms shall be provided along with fall restraint/protection tie offs.

IV. For all roofs greater than 4/12 pitch a level platform shall be provided, along with appropriate fall restraint/protection.

V. Roofs greater than a 4/12 pitch must have other access for hoisting gear other than a rope at the roof's edge.

VI. Power lines must not impede access to source, nor interfere with sampling. In general, 25' clearance is desired from hot (energized) power lines.

VII. Lighting shall be adequate to illuminate roof in event of darkness.

VIII. Snow, ice, and hail must be cleared from any pitched roof before sampling.

IX. Stacks must extend well above head level to prevent exhaust fumes from blowing in face or scorching hair during wind shifts.

X. Extension ladders used for access must be tied off to building and secured at the base.

Miscellaneous Concerns

XI. Permanent metal ladders attached to buildings for roof access **must** meet OSHA guidelines.

XII. Source operators wishing testers to work on unsafe roofs are itching for a fight, and should do their own tests.

XIII. Gas cylinders will **not** be allowed on a pitched roof without adequate, OSHA approved, restraint.

XIV. Roof top cleanliness (e.g.) standing water, slippery substances, and loose/extra junk scattered around roof.

XV. Adverse weather conditions (e.g.) high winds, snow, ice, lightning, etc.

XVI. Maximum extension ladder height to roof 25 feet.

XVII. On pitched roofs, **no** work is to be done while standing on a ladder. Ladder use for supporting gear is ok, as long as ladder is secure.

XVIII. For sheet metal roofs, beam supports should be no more than 36 inches apart. If more, a walkway **shall** be provided.

XIX. Shoes with good traction should be given preference over steel-toed boots.

XX. Roof hatches **should** be operable from above, so they are not left open.

XXI. Sampling on pitched roofs should be done in tandem for safety.

XXII. Nearby vents on the roof that can pose safety problems (e. g. pressure reliefs venting

superheated steam, noise vents, toxic fume vents, bypass vents) should be identified before work begins. If the sampling must be done near any of these, make arrangements to protect workers from them.

III. OSHA MINIMUMS

Roof Integrity

Condition: OSHA 29 CFR 1926.501 (a)(2); Employer shall determine if the walking/working surface on which the employee works is safe.

Hazards

Protection from falling objects: OSHA subpart M (1926.501 paragraph (c1-3)): when exposed to falling objects the employer shall have the employee wear a hard-hat and implement one of the following measures: Toe boards, screens, guardrails, canopy or a barricade to contain objects that may fall.

Fall Restraint Requirements

Height above ground: 6 feet or more shall be protected from falling

Pitch: OSHA subpart M (1926.501 paragraph (b11)): steep pitch is a roof having a slope greater than 4 in 12 for normal roof (vertical to horizontal) 8 in 12 for tile and metal roofs shall be protected from falling.

OSHA subpart M (1926.501 paragraph (b10)): Low sloped roofs with unprotected sides 6 feet or more above lower levels shall protect from falling by guardrail, safety net, personal fall arrest, or a combination of warning line system (OSHA subpart M 1926.502 paragraph (f)(1)(i,ii)) line shall be erected not less than 6 feet from the edge) and guard rail, safety net, personnel fall arrest, or safety monitoring system.

Skylights/holes: OSHA subpart M (1926.501 paragraph (b9)(4)(I)): employees shall be protected by Personal fall arrest systems, covers, or guard rails

Unprotected sides and edges: OSHA subpart M (1926.501 paragraph (b1)): Each employee on a walking/working surface with and unprotected side of edges which is 6 feet or more above a lower level shall be protected from falling by using guard rails, safety nets, or personal fall arrest system.

Railing Requirements OSHA subpart M (1926.502 paragraph (b1-15))

Height: (b)(1) 42 inches +/- 3 inches

Midrails: (b)(2)midrails, screens, mesh or intermediate vertical member shall be installed between top edge and walking surface when there is not wall or parapet wall at least 21 inches high.

Posts: (b)(2)(iv)shall be no more than 19 inches apart.

Strength: (b)(4) shall be capable of withstanding without failure a force of at least 200 pounds within 2 inches of the top edge (midrail 150 pounds) in any outward/downward direction at any point along the top edge.

Hoisting: (b)(10) When guard rail systems are used at hoisting areas, a chain, gate or removable guardrail section shall be placed at the opening.

Entry/exits:

Warning lines: OSHA subpart M (1926.502 paragraph (f2-3)): Shall consist of ropes, wire, or chain (with a minimum tensile strength of 500 pounds) at not more than 6-foot intervals with high visibility material. It shall be supported in such a way that its lowest point is no less than 34 inches and the highest point no more than 39 inches. It shall be capable of with standing a force of 16 pounds applied horizontally against the stanchions without tipping. No employee shall be allowed in the area between a roof edge and a warning line unless the employee is performing work in that area.

Attachment Points

Roof Anchors: OSHA Subpart M (1926.502 (d)(15)): anchorages used for attachment of personal fall arrest equipment shall be independent of any anchorage being used to support or suspend platforms and capable of supporting at least 5,000 pounds per employee(310 pounds w/equipment) attached.

Fall Protection Plan

OSHA Subpart M (1926.502 (k)(1-4)) ...for leading edge work, or residential construction work and who can demonstrate that it is infeasible or it creates a greater hazard to use conventional fall protection equipment. It must be prepared by a qualified person, and changes must be approved by a qualified person and it shall be maintained at the job site and implemented by a competent person. (k)(5) It shall include reason why the use of conventional fall protection systems are infeasible or why their use would create a greater hazard.(k)(6,7) The plan shall include the location where fall protection cannot be used and the discussion of other measures that will be taken to reduce or eliminate the fall hazard for workers who cannot be provided with fall protection. It must also comply with the criteria in section (g) control zones or at minimum section (h) a safety monitoring system.

(k)(10) In the event of a fall, or some other related, serious incident occurs(e.g. a near miss) the employer shall investigate the circumstances of the fall or other incident to determine if the fall protection plan needs to be changed and shall implement those changes to prevent similar types of incidents.

Toe Boards Requirements

Mainly for protection of items being used and personnel located below the work area, not for personal fall protection.

Scaffolding Requirements

Scaffolding should be installed by professional installers.

A. Scaffold required on job shall be free from defects, and conform to following, as well as provisions of OSHA regulations.

B. Planking shall be scaffold grade lumber; extended 6 inches to 12 inches over end supports and overlapped at interior supports minimum of 12 inches. If plank ends are cleated, overhang can be wide enough only to provide room for cleats. Safely secure planking to prevent movement, lateral or otherwise.

C. Light-duty scaffold platforms may be built of 5/8 inch thick plywood, supported at least every 2 feet and safely secured against movement.

D. Guardrails shall be installed on open sides of scaffold platforms which are more than 6 feet high. When platform is less than 45 inches in width, guardrails shall be provided for platforms over 4 feet high above ground or floor.

E. When required, scaffolds shall have guardrails consisting of top rail (2 x 4 lumber), mid-rail (1 x 6 lumber), toeboard (1 x 4 lumber) around platform perimeter, and posts (2 x 4 lumber) or approved equivalent. Height of top rail shall be 42 inches, and supporting vertical posts shall be spaced not to exceed 8 feet on center. (Lumber sizes are nominal) Guardrail shall be capable of withstanding a concentrated load of 200 pounds applied at any point and any direction at top rail.

F. When necessary, persons using scaffolds shall provide protection, such as screens and barricades, for personnel below scaffold. Post appropriate warning signs.

ROLLING MOBILE TUBE-&-COUPLER AND TUBULAR SCAFFOLDS

A. Height-to-width ratio shall be no greater than 2:1 for rolling scaffold while it is being moved.

B. Locking device shall be provided for each scaffold wheel. Scaffold workers are responsible for locking wheels, which shall be kept locked except during relocation of scaffold.

C. Secure or remove tools and materials from platform before moving scaffold.

D. Do not ride on moving rolling scaffold.

SUSPENDED SCAFFOLDS

A. Open sides of suspended scaffold shall be provided with 18 gauge, ½ inch mesh galvanized screens or equivalent, full height from toeboard to top rail.

B. Ropes, slings, hangers, platforms and other supporting parts shall be inspected before every installation.

C. Multiple-point suspended scaffolds shall be designed by a registered professional engineer.

D. Installation of mason's adjustable multiple-point suspended scaffolds (or equivalent) shall be in accordance with Engineering drawings or specifications.

E. Roof (cornice) hooks shall not be used as roof attachments for suspended scaffolds.

F. Protection of roofing, drip edge, and flashing shall be provided. Should any damage occur to roofing components, immediately notify Execution Representative (to be defined).

G. Be sure scaffold is kept clear of obstructions during raising and lowering operations.

H. Only two (2) persons shall be allowed to work at one time on 2-point suspension scaffold or on each tier of a 2-point suspension multi-tier scaffold.

I. Personnel exposed to overhead hazards on scaffolds shall wear hard hats or be provided with overhead protection.

J. Anchor or lower to ground unoccupied scaffolds.

OUTRIGGERS FOR 2-POINT SUSPENDED SCAFFOLDS

Outrigger systems shall be designed by a registered professional engineer to meet following requirements. A stamped drawing, as proof of compliance, shall be presented to Execution Representative. Any deviation from standard shall be approved be a registered professional engineer.

A. Specify maximum outboard length. (Outboard length to mean distance between fulcrum point and center line of suspension rope)

B. Inboard length of beam shall not be less than two (2) times outboard length. (Inboard length to mean distance from fulcrum point to center line of anchorage or center of gravity of counterweights.)

C. Outrigger beam design shall consider lateral stability of its flanges.

D. Outrigger beams shall be steel or aluminum wide-flange sections, with webs vertical.

E. Inboard ends of outrigger beams shall be securely anchored by counterweights, struts bearing against overhead beams or ceiling or by a tension tie to floor beam.

F. Counterweights shall be steel, lead, concrete, or other durable material and locked on, to prevent removal by unauthorized personnel. Do not use sandbags or water-filled containers.

G. Brace outrigger beams together at inboard ends at a fulcrum point to prevent tipping or lateral movement.

H. If suspension cable is hung by a choker wrapped around a beam, a stop bolt shall be provided at the outboard end of each outrigger beam. Preferable method is to provide hold in beam web, and attach cable with shackle through hole.

I. Suspension ropes shall be steel and capable of supporting six (6) times ultimate dead and live loads.

J. Other components, including counterweights, shall be capable of supporting four (4) times rated dead and live loads.

SUSPENSION AND PLATFORM SYSTEM

A. For hand-operated type:

- Raise scaffold with ratchet jack handle. Wind hoisting cable even on drum
- Lower scaffold with hand crank. Never wire or wedge open pawl.

B. Power-operated scaffolds shall be equipped with UL or FM approved electric or air-operated hoisting machines. Manually operated winches shall also be UL or FM approved.

C. Platform width shall be between 20 inches and 36 inches.

D. Platform shall be securely fastened to hangers by U-bolts or equivalent means.

E. Hangers shall be capable of sustaining four (4) times maximum rated load and shall be designed with support for guardrail, intermediate rail, and toeboard.

F. When occupied, scaffold cannot be tied into building - an inside railing shall be provided.

SAFETY HARNESSES, LANYARDS, AND LIFELINES

A. Parachute-type harnesses shall be worn by personnel while working on suspended and float scaffolds.

B. Safety harness and lanyard hardware shall be drop-forged or pressed steel and capable of withstanding tensile loading of 4,000 pounds. A shock-absorbing device is recommended for use with the lanyard.

C. Safety harness lanyard shall be a minimum ½ inch nylon (or equivalent) with maximum length to be provided for a fall no greater than 6 feet. Nominal breaking strength shall be no less than 5,400 pounds.

D. Safety harness with lanyard shall be securely attached to approved lifeline by means of snubbing device. Approved snubber (rope grab) shall be properly secured to lifeline and shall be adjusted by hand to maintain a height above level of worker's head.

E. Lifelines shall be nylon (or equivalent) with minimum breaking strength of 5,400 pounds and of adequate length to reach proper landing point, with no excessive rope coil.

F. Lifelines shall not be used to support suspended scaffolds.

G. Use lifelines only for purpose for which they are intended.

H. On single-tier scaffold, or top tier of a multi-tier scaffold, each person will be tied off to a separate safety line, securely attached to building.

I. On lower ties of a multi-tier scaffold, each person will be tied off to separate lifelines, securely attached to scaffold.

J. Dispose of lifelines, safety belts, or lanyards actually subjected to in-service loading.

K. Contractor is responsible for:

- Daily inspection of their safety equipment, ensuring that it is properly secured and in good physical condition.
- Checking to see that anti-chafing protection is in place.
- Making sure that lifelines are kept clear of obstructions.
- Using extreme caution with welding, sandblasting, and similar equipment to ensure that these operations will not damage lifelines or scaffold components.

WORK PLATFORMS

A. Operators of engine-, electric-, or battery-powered, self-propelled, vehicle-mounted aerial platforms shall be trained and qualified personnel.

B. Personnel working from such work platforms shall wear safety harness attached to lanyard, which in turn is attached to platform, boom or other firm support.

C. Workers shall remain on work platform and shall not step up on guardrails.

D. Riding on an elevated work platform while vehicle is moving is prohibited.

Exception: When repositioning the work platform for short distances (i.e., moving ahead several feet to reach next junction, connection, or position, as job progresses).

E. For operations requiring a worker to leave an elevated work platform:

- Execution Representative approval is required.
- A body harness and hard hat shall be worn.
- Lanyard shall be connected to a firm support.

ARTICULATED AERIAL PLATFORM (PITMAN, REACH-ALL OR EQUIVALENT)

A. Total weight of load shall not exceed lifting capacity of lift.

B. Load shall be properly distributed to prevent tipping.

C. Be sure that outriggers are set before platform is raised.

HI-LIFT LOADER (LULL, SKYTRACK OR EQUIVALENT)

A special approved platform shall be attached to forks for lifting personnel.

PORTABLE TELESCOPING WORK PLATFORMS (LANGLEY OR EQUIVALENT)

A. Wheel locks and platform lock shall be in locked position when platform is in use.

B. Operators are prohibited from riding platforms that are being moved to another location.

C. Be sure that platforms are set on firm, substantially level surface.

D. Get on and off at ground level only.

E. Keep safety chain fastened during work operations.

F. Securely fix accessories, containers, tools, or other materials on working platform to prevent their moving or falling off.

G. Do not use auxiliary scaffolding, ladders, etc., to extend normal reach of work platform.

H. Langley platforms must be used with outriggers extended and lockdown activated before operating the platform at a height greater than 11 feet.

Training

In the United States several government agencies have training requirements for their various safety standards. Most safety training requirements come from the Occupational Safety and Health Administration (OSHA), but the Department of Transportation (DOT), the Mine Safety and Health Administration (MSHA), the Department of Public Health all have training requirements that effect the source testing industry.

Many of the older OSHA standards and almost all of the newer or revised standards have specific training requirements. Those standards that may apply to source testing and their references are listed below:

29 CFR PART 1910

OCCUPATIONAL SAFETY AND HEALTH STANDARDS

Subpart D - Walking -Working Surfaces

- 1910.21 through 1910.32 pertains to guarding floor and wall openings, ladders, stairs and scaffolding.

Subpart E - Means of Egress

- 1910.35 through 1910.40 plus appendix includes emergency planning.

Subpart F - Powered Platforms, Manlifts, and Vehicle-mounted Work Platforms

- 1910.66 through 1910.70

Subpart G - Occupational Health and Environmental Control

- 1910.94 through 1910.100 pertains to ventilation, noise exposure and radiation.

Subpart H - Hazardous Materials

- 1910.102 through 1910.120 pertains to compressed gasses and flammable liquids.
- 1910.119 Process safety management of highly hazardous chemicals. There are site specific training requirements for people who work at plants that are affected by this standard.
- 1910.120 Hazardous waste operations and emergency response. There is a 40 hr. safety training requirement for people who work at these sites. (HAZWOPPER)

Subpart I - Personal Protective Equipment

- 1910.132 through 1910.140 pertains to eye, face, respiratory, head, foot and hand protection equipment.

Subpart J - General Environmental Controls

- 1910.146 Confined Spaces
- 1910.147 Lockout - Tagout

Subpart K - Medical and First Aid

- 1910.151

Subpart L - Fire Protection

- 1910.157 Portable Fire Extinguishers

Subpart N -Materials Handling and Storage

- 1910.184 Slings

Subpart O - Machine Guarding

- 1910.211 through 1910.222

Subpart S - Electrical

- 1910.301 through 1910.399

Subpart Z - Toxic and Hazardous Substances

- 1910.1000 Air Contaminants
- 1910.1001 Asbestos
- 1910.1002 through 1910.1051 Various hazardous substances
- 1910.1052 Methylene Chloride
- 1910.1200 Hazard Communication
- 1910.1450 Occupational Exposure to Hazardous Chemicals in the Laboratory

49 CFR DEPARTMENT OF TRANSPORTATION

Parts 107 through 178 pertains to shipping or transporting hazardous materials.

42 CFR DEPARTMENT OF PUBLIC HEALTH

Part 84 pertains to a respiratory protection program for particulates.

30 CFR MINERAL RESOURCES

This the title that includes all of the Mine Safety regulations. Most of these standards mimic the OSHA standards but are specific for the industries governed by 30 CFR like mining operations or cement plants.

In addition to these specific standards, OSHA has something called the “General Duty Clause” which basically states that employers must provide a workplace free of recognized hazards that are likely to cause death or serious physical harm to employees. In regards to training, OSHA has interpreted this to mean that if a risk is present the employee must be made aware of the risk and how that risk will be controlled.

Training is the single most important tool available in the two step accident and injury prevention process.

Step #1 IDENTIFY HAZARD OR RISK

Step #2 CONTROL HAZARD OR RISK

WHEN SHOULD TRAINING OCCUR?

It is recommended that all new employees receive an orientation at the time of hire. During this orientation they should be made aware of all serious hazards and the procedures used to control those hazards. OSHA and all of the other government agencies listed before require that training takes place before the employee is exposed to a hazard. In some cases they specify a time period when training must occur; for example DOT requires that the hazardous materials for transportation training must take place within 90 days. It is recommended that refresher training is done periodically, as needed, especially prior to performing hazardous task that are done infrequently.

The following outlines can be used as training aides.

ACCIDENT PREVENTION

Step #1. IDENTIFY HAZARD OR RISK

Hazard Types

- Physical
- Chemical
- Biological
- Psychological

Hazard Causes

- Unsafe Environment
- Unsafe Equipment
- Unsafe Procedures
- Unsafe Behavior

Step #2. CONTROL HAZARD OR RISK

Administrative controls: Prevent the hazardous situation.

- Policies
- Procedures
- Training

Engineering controls: Remove the exposure before it reaches the employee.

- Substitution
- Isolation
- Ventilation

Personal Protective Equipment: Prevent exposure from reaching employee.

OVERVIEW OF TYPICAL STACK TESTING SAFETY AND HEALTH HAZARDS

There are four broad categories of hazards.

1. Physical hazards
2. Chemical hazards
3. Biological hazards
4. Psychological Hazards or Contributors

PHYSICAL HAZARDS

Hazard / Effects

1.	Noise:	hearing loss, distraction, headaches, irritability
2.	Heat:	heat syncope (fainting), heat rash, heat cramps, heat exhaustion, heat stroke

3.	Cold:	loss of dexterity, frostbite, hypothermia
4.	Rain:	falls on slippery surfaces, increased potential for electrical shock, increased potential for burns when gloves get wet
5.	Wind:	can cause unstable conditions for people and equipment, can cause eye injuries
6.	Lightning:	can cause electrocution
7.	Darkness:	increases potential for slips and falls
8.	Gravity:	causes slips and falls and falling objects
9.	Hot objects:	causes burns
10.	Sharp object::	causes lacerations
11.	Electricity:	causes electrical shocks
12.	Vibration:	can cause neurological or muscular disorders
13.	Radiation	can cause numerous health effects

CHEMICAL HAZARDS

Forms of chemical hazards:

- Liquids
- Solids
- Vapors and gases
- Airborne particulates

Chemical hazards

1. Organic solvents
2. Metals
3. Acids
4. Caustics
5. Combustion byproducts
6. Petroleum distillates

7. Mineral dusts
    8. Poison gases
    9. Compressed gases

Chemical hazard effects (chronic or acute)

1. Skin irritation
2. Neurological damage
3. Reproductive system damage
4. Pneumoconiosis
5. Sensitization
6. Asphyxiation
7. Cardiovascular damage
8. Cancer
9. Target organ damage

BIOLOGICAL HAZARDS

1. Insects
2. Animals (birds, bats, rodents)
3. Animal waste
4. Certain plants (poison ivy)
5. Pollens
6. Fungi
7. Bacteria
8. Viruses
9. Infectious waste
10. Blood borne pathogens

PSYCHOLOGICAL HAZARDS OR MISCELLANEOUS CONTRIBUTORS

1. Stress
2. Fatigue
3. Rushing
4. Attitude
5. Complacency