Pressure Vessel Newsletter

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From The Editor's Desk:

Mainstream sciences like physics, chemistry, astronomy etc. are always pushing at the frontier of their respective disciplines. Work on unified theory, understanding of gravity, space-time phenomenon and discovery of new materials are ongoing and likely to produce exciting results for the foreseeable future. Engineering disciplines like pressure vessels are more application related, and therefore do not lend themselves to similar discoveries or inventions.

However, that is not to say technological advances are not taking place in the world of pressure vessels. The rapid rate of improvement with digital computers have made significant impact on the design and analyses of pressure vessels, and have led to a complete re-haul of the ASME Section VIII, Division 2 code. Because of the rapid development of finite element software coupled with continuing increase in computing speed and storage capacity of the computer, we are able to accomplish detailed finite element analyses routinely and sometimes even in interactive mode.

Major refinements in the areas of materials and fabrication have been achieved that include better control of material elements, improved processing techniques, ability to tailor materials for specific environment, high deposition rates for welding, and automated welding through robotics. Similarly, there have been advances in non-destructive examination (NDE) methods of ultrasonics, eddy current, x-ray, and acoustic emission techniques that have helped in upgrading the manufacturing quality, doing better job at in-service inspection, and preventing or reducing failures.

Of course, there are many challenges we must overcome in the coming years. In the short term, in my view, we must concentrate our collective resources towards *predictive engineering*; i.e., to correlate the forces on pressure vessels first to the changes in material at atomic level, and then to predict the eventual failure of the material. This will provide us with an advance warning system for as-needed maintenance as opposed to the current norm of performing maintenance at regular intervals. I believe this will lead to longer intervals between subsequent repairs/ replacements and will result in extended life of the pressure vessels.

Ramesh K Tiwari

In this issue…

Storage Tanks

A FACILITY OWNER/ OPERATOR'S GUIDE TO OIL POLLUTION PREVENTION

Facilities with aboveground storage tanks (ASTs) in U.S. holding oils of any kind are generally subjected to U.S. EPA's Spill Prevention, Control and Countermeasure (SPCC) regulations that is in 40 CFR Part 112. The SPCC regulation does not specifically use the term AST, but rather includes ASTs under the term bulk storage container. A bulk storage container is "any container used to store oil. The containers are used for purposes of including, but not limited to, the storage of oil prior to use, while being used, or prior to further distribution in commerce."

During storage, transport, or as a result of energy exploration and production activities, oil and other oil-based products are sometimes spilled onto land or into waterways. These spills endanger public health, impact drinking water, devastate natural resources, and disrupt the economy. Every effort must be made to prevent oil spills and to clean them up promptly once they occur. The costs associated with spill prevention are often much less than the costs associated with spill clean-up, fines, and other civil liabilities. The purpose of SPCC rule is to help facilities prevent a discharge of oil into navigable waters or adjoining shorelines.

AN OUNCE OF PREVENTION IS WORTH A POUND OF CURE

Who is covered by SPCC rule?

A facility is covered by SPCC rule if it has an aggregate aboveground oil storage capacity greater than 1,320 U.S. gallons, or a completely buried storage capacity greater than 42,000 U.S. gallons, and there is a reasonable expectation of an oil discharge into or upon navigable waters of the U.S. or adjoining shorelines.

What type of oil are covered?

Oil of any type and in any form is covered, including, but not limited to:

- Petroleum,
- Fuel oil,
- Sludge,
- Oil refuse,
- Oil mixed with wastes other than dredged spoil
- Fats, oils or greases of animal, fish or marine mammal origin

- vegetable oils, including oil from seeds, nuts, fruits, or kernels
- other oils and greases, including synthetic oils and mineral oils

What kinds of facilities are covered?

A facility that stores, processes, refines, uses or consumes oil and is non-transportation-related is potentially subject to SPCC rule. Operations that are intended to move oil from one location to another, i.e., transportation-related, are not included. Here are some examples of covered facilities and operations:

- Onshore and offshore oil well drilling facilities
- Onshore and offshore oil production facilities (including separators and storage facilities)
- Oil refining or storage facilities
- Industrial commercial, agricultural, or public facilities using or storing oil
- Certain waste treatment facilities
- Loading racks, transfer hoses, loading arms, and other equipment
- Vehicles (e.g. tank trucks) and railroad cars used to transport oil exclusively within the confines of a facility

Oil Drilling

Oil Production

Oil Storage

Power Generators

Oil Refineries

Construction Sites

Airports

Farms and Ranches

Marinas

Fish Canneries

Power Transmission and Distribution

What kinds of activities are typically not covered?

Here are some examples of transportation-related activities or equipment typically not covered by the SPCC rule:

- Interstate or inter-facility oil pipeline systems
- Oil transported in vessels (i.e. ships, barges)
- Oil transported between facilities by rail car or tanker truck

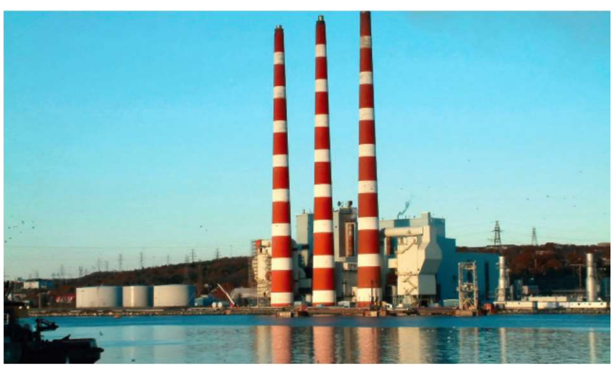
How do I calculate oil storage capacity?

Use the shell capacity of the container (maximum volume) and not the actual amount of product stored in the container (operational volume) to determine whether the SPCC rule applies to you. Count only containers with storage capacity equal to or greater than 55 U.S. gallons. Simply add up the container oil storage capacities and compare your total facility capacity to the SPCC threshold: total aboveground oil storage capacity greater than 1,320 U.S. gallons; or completely buried oil storage capacity greater than 42,000 U.S. gallons. Examples of oil storage containers at a facility that *do* count toward facility storage capacity:

<u>Bulk storage containers</u>: ASTs (either shop built or field erected tanks); certain completely buried tanks; partially buries tanks; tanks in vaults; bunkered tanks; and mobile or portable containers such as drums, totes, non-transportation-related tank trucks, and mobile refuelers.

<u>Oil filled equipment</u>: May include electrical or operating equipment such as hydraulic systems, lubricating systems (e.g. those for pumps, compressors and other rotating equipment, including pumpjack lubrication systems), gear boxes, machining coolant systems, heat transfer systems, transformers, circuit breakers and electrical switches; or manufacturing equipment such as process vessels, or other equipment used in alteration, processing or refining of crude oil and other non-petroleum oils, including animal fats and vegetable oils.

How can I determine if my facility could reasonably discharge oil into or upon navigable waters or adjoining shorelines?



You can determine this by considering the geography and location of your facility relative to nearby navigable waters (such as streams, creeks and other waterways). Additionally, you should determine if ditches, gullies, storm sewers or other drainage systems may transport an oil spill to nearby streams. Estimate the volume of oil that could be spilled in an incident and how that oil might drain or flow from your facility and soil conditions or geographic features that might affect the flow toward waterways. Also you may want to consider whether precipitation runoff could transport oil into navigable waters or adjoining shorelines. You may not take into account manmade features such as dikes, equipment or other structures that might prevent, contain, hinder or restrain the flow of oil. Assume these manmade features are not present when making your determination. If you consider the applicable factors described above and determine a spill can reasonably flow to a waterway, then you must comply with the SPCC rule.

What do covered facilities have to do?

A facility that meets the criteria above must comply with the SPCC rule by preventing oil spills and developing and implementing an SPCC Plan.

Prevent oil spills: Steps that a facility owner/ operator can take to prevent oil spills include:

- Using containers suitable for oil stored. For example use a container designed for flammable liquids to store gasoline;

- Providing overfill prevention for your oil storage containers. You could use a high-level alarm or audible vent;
- Providing sized secondary containment for bulk storage containers, such as dike or a remote impoundment. The containment needs to hold the full capacity of the container plus possible rainfall. The dike may be constructed of earth or concrete. A double walled tank may also suffice.
- Providing general secondary containment to catch the most likely oil spill where you transfer oil to and from containers and for mobile refuelers and tanker trucks. For example, you may use sorbent materials, drip pans or curbing for these areas; and
- Periodically inspecting and testing pipes and containers. You need to visually inspect aboveground pipes and oil containers according to industry standards; buried pipes need to be leak tested when they are installed or repaired. Include a written record of inspections in the Plan.

Prepare and implement an SPCC Plan: The owner or operator of the facility must develop and implement an SPCC Plan that describes oil handling operations, spill prevention practices, discharge or drainage controls, and the personnel, equipment and resources at the facility that are used to prevent oil spills from reaching navigable waters or adjoining shorelines. Although each SPCC Plan is unique to the facility, there are certain elements that must be described in every Plan including:

- Operating procedures at the facility to prevent oil spills;
- Control measures (such as secondary containment) installed to prevent oil spills from entering navigable waters or adjoining shorelines; and
- Countermeasures to contain, cleanup, and mitigate the effects of an oil spill that has impacted navigable waters or adjoining shorelines.

Important Elements of an SPCC Plan:

- **Facility diagram and description of the facility**
- **Oil discharge predictions**
- **Appropriate secondary containment or diversionary structures**
- **Facility drainage**
- **Site security**
- **Facility Inspections**
- **Requirements for bulk storage containers including inspections, overfill, and integrity testing requirements**
- **Transfer procedures and equipment (including piping)**
- **Requirements for qualified oil-filled operational equipment**
- **Loading/ unloading rack requirements and procedures for tank cars and tank trucks**
- **Brittle fracture evaluations for aboveground field constructed containers**
- **Personnel training and oil discharge prevention briefings**
- **Recordkeeping requirements**
- **Five year Plan review**
- **Management approval**
- **Plan certification (by a Professional Engineer or in certain cases by the facility owner/ operator)**

Every SPCC Plan must be prepared in accordance with good engineering practices. Every SPCC Plan must be certified by a Professional Engineer unless the owner/ operator is able to, and chooses to, self-certify the Plan.

No matter who certifies the Plan, remember that ultimately the owner/ operator is responsible for complying with the rule.

Who can certify the SPCC Plan?

Preparation of the SPCC Plan is the responsibility of the facility owner/ operator, who may also be eligible to self-certify the SPCC Plan if the facility meets the following eligibility criteria for a qualified facility:

1. Total aboveground oil storage capacity of 10,000 U.S. gallons or less, and
2. In the 3 years prior to the date the SPCC Plan is certified, the facility has had no single discharge of oil to navigable waters or adjoining shorelines exceeding 1,000 U.S. gallons, or no two discharges of oil to navigable waters or adjoining shorelines each exceeding 42 U.S. gallons within any 12-month period. This does not include discharges that are the result of natural disasters, acts of war, or terrorism. When determining the applicability of the SPCC reporting requirements, the gallon(s) amount specified (either 1,000 or 42) refers to the amount of oil that actually reached navigable waters or adjoining shorelines no the total amount of oil spilled. EPA considers the entire volume of the discharge to be oil for the purposes of these reporting requirements.

If the facility does not meet the above criteria, the SPCC Plan must be certified by a licensed Professional Engineer. By certifying the SPCC Plan, the PE confirms that:

1. He/ she is familiar with the requirements of the rule;
2. He/ she or an agent has visited and examined the facility;
3. The SPCC Plan has been prepared in accordance with good engineering practices, including consideration of applicable industry standards, and with the requirements of the rule;
4. Procedures for required inspections and testing have been established; and
5. The SPCC Plan is adequate for the facility.

When self-certifying a facility's SPCC Plan, the owner/ operator makes a similar statement.

Did you know

A spill of only *one* gallon of oil can contaminate a *million* gallons of water.

How do I ask for an extension of time to prepare and implement SPCC Plan?

If you are unable to prepare or amend and fully implement your SPCC Plan by the compliance date due to either non-availability of qualified personnel, or delays in construction or equipment delivery beyond the control of owner/ operator, then you may request an extension from your EPA Regional Administrator (RA). A list of EPA Regional Offices is provided at the end of this article. The written request for an extension to the RA must include:

- A full explanation of the cause for any such delay and the specific aspects of the SPCC Plan affected by the delay;
- A full discussion of actions being taken or contemplated to minimize or mitigate such delay; and
- A proposed time schedule for the implementation of any corrective actions being taken or contemplated, including interim dates for completion of tests or studies, installation and operation of any necessary equipment, or other preventive measures.

You may present additional oral or written statement in support of your extension request. The extension request does not relieve you of your obligation to comply with the requirements of the rule. The RA may request a copy of your SPCC Plan to evaluate the extension request.

If the RA approves an extension of time for particular equipment or other specific aspects of the SPCC Plan, you must still comply with SPCC requirements not covered by the extension.

Do I need to submit the SPCC Plan to EPA?

No, SPCC Plans should be maintained at any facility normally attended at least four hours per day, or at the nearest field office if the facility is not so staffed. Submit your Plan to EPA only when requested.

What should I do if I have a spill?

If your facility discharges oil to navigable waters or adjoining shorelines, you are required to follow certain federal reporting requirements. Any person in charge of an onshore or offshore facility must notify the National Response Center (NRC) immediately after he/ she has knowledge of the discharge. The NRC is the federal government's centralized reporting center, which is staffed 24 hours per day by U.S. Coast Guard Personnel.

A common misunderstanding is that by reporting to the NRC you have met state and local reporting requirements. The report to the NRC satisfies only your federal reporting requirements under the Clean Water Act. Additional state and local reporting requirements may apply. In most cases, it makes sense to call 911 in the event of an oil spill, particularly in the case of flammable or combustible oils spills.

The owner/ operator of a facility regulated by the SPCC rule must also report the discharge to EPA when:

- More than 1,000 U.S. gallons of oil is discharged to navigable waters or adjoining shorelines in a single event; or
- More than 42 U.S. gallons of oil in each of two discharges to navigable waters or adjoining shorelines occurs within any twelve-month period.

Note: The gallons amount(s) specified (either 1,000 or 42) refers to the amount of oil that actually reaches navigable waters or adjoining shorelines, not the total amount of oil spilled. EPA considers the entire volume of discharge to be oil for the purposes of these reporting requirements.

After the NRC has been notified, the owner/ operator must provide the following information to the RA:

- Name and location of the facility
- Owner/ operator name
- Maximum storage/ handling capacity of the facility and normal daily throughput
- Corrective actions and countermeasures taken, including descriptions of equipment repairs and replacements
- Adequate description of the facility, including maps, flow diagrams, and topographical maps, as necessary
- Cause of the discharge to navigable waters, including a failure analysis
- Failure analysis of the system where the discharge occurred
- Additional preventive measures taken or planned to take to minimize discharge reoccurrence

The RA may require additional information. You must also send a copy of this information to the agency or agencies in charge of oil pollution control activities in the state in which SPCC-regulated facility is located.

EPA OFFICES

U.S. EPA Headquarters
Office of Emergency Management
Ariel Rios Building – Mail Code 5104A
1200 Pennsylvania Avenue
Washington, DC 20460

U.S. EPA Region I
5 Post Office Square, Suite 100
Boston, MA 02109-3912

CT, ME, MA, NH, RI, and VT

U.S. EPA Region II
2890 Woodbridge Avenue
Building 209 (MS 211)
Edison, NJ 08837-3679

NJ, NY, PR, and USVI

U.S. EPA Region III
1650 Arch Street (3HS61)
Philadelphia, PA 19103-2029

DE, DC, MD, PA, VA, and WV

U.S. EPA Region IV
61 Forsyth Street
Atlanta, GA 30365-3415

AL, FL, GA, KY, MS, NC, SC, and TN

U.S. EPA Region V
77 West Jackson Blvd (SE-5J)
Chicago, IL 60604-3590

IL, IN, MI, MN, OH, and WI

U.S. EPA Region VI
1445 Ross Avenue (6SF-RO)
Dallas, TX 75202-2733

AR, LA, NM, OK, and TX

U.S. EPA Region VII
901 North 5th Street
Kansas City, KS 66101

IA, KS, MO, and NE

U.S. EPA Region VIII
1595 Wynkoop Street (8EPR-ER)
Denver, CO 80202-1129

CO, MT, ND, SD, UT, and WY

U.S. EPA Region IX
77 Hawthorne St (SFD-9-4)
San Francisco, CA 94105

AZ, CA, HI, NV, AS, and GU

U.S. EPA Region X
1200 6th Avenue (ECL-116)
Seattle, WA 98101

AK, ID, OR, and WA

U.S. EPA Alaska Operations Office
222 West 7th Avenue, #19
Anchorage, AK 99513-7588

Source: Spill Prevention, Control, and Countermeasure (SPCC) Regulation
40 CFR Part 112
A Facility Owner/ Operator's Guide to Oil Pollution Prevention

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Heat Exchangers

HEAT EXCHANGER CLEANING

Introduction

Refineries and chemical plants depend on clean heat exchangers to maintain efficient plant operation. But over time, heat exchangers can build up fouling on both the tube side and the shell side of the tube bundle. As fouling increases, heat transfer is compromised and efficiency is diminished, resulting in reduced throughput as well as increased energy requirements. For example, as crude preheat exchangers foul, the crude temperature entering the furnace is reduced, and additional fuel is required to fire the furnace. In case of tower overhead exchangers, fouling can result in higher tower pressures, which impedes throughput and/ or fractionation quality.

This article discusses cleaning methods to bring the heat exchanger tube surfaces to the original clean conditions. This ensures the optimum heat transfer efficiency and increased life expectancy of the tubes. The probability of success in cleaning the heat exchanger is dependent upon the selection of the appropriate cleaning technique under the specific fouling condition. Early identification of fouling characteristics and a fundamental knowledge of cleaning system capabilities are essential in determining the most effective cleaning technique as well as the required frequency of cleaning.

While cleaning can be performed *on-line*, the majority of cleaning procedures are performed *off*-line. The most frequently chosen, the most effective and fastest cleaning method is mechanical cleaning. Another off-line cleaning method is the use of very high pressure water, but since the jet can only be moved along the tube slowly, the time taken to clean the heat exchanger can become extended. Also great care must be taken to avoid damaging any tube sheet or tube coatings which may be present.

Mechanical Cleaning of Heat Exchangers

<u>Off line mechanical cleaning</u> is especially useful where fouling problems exist and are too severe to be handled by any of the other methods. The tool selected has to be appropriate for removing the particular type of deposit.

- Molded plastic cleaners (pigs) are quite popular for some light silt applications. Brushes can also be used to remove these soft deposits as well as some microbiological deposits. Brushes are also useful for cleaning tubes with enhanced surfaces (e.g. spirally indented or finned), or those tubes with thin wall metal inserts or epoxy type coatings.
- With harder type of deposits, calcium carbonate being a notable example, metal cleaners of various designs have been developed for effective removal. The blades are mounted on a spindle, at one end of the spindle is a serrated plastic disk that allows a jet of water to propel the cleaners through a tube with greater hydraulic efficiency. The water is delivered by a pump operating at 300 psig (2.07MPa). Since the pump is usually mounted on a wheeled base plate, the system can be conveniently moved from unit to unit within a plant or even moved to another plant.

  Most metal cleaners are designed to have a controlled spring loaded cutting edge: but, if effective deposit removal is to be the result, the dimensions of the cutting surfaces have to be closely matched to the internal diameter of the tube being cleaned. This not only improves the peripheral surface contact, but also ensures that the appropriate spring tension will be applied as the cleaner is propelled through the tube. The effective life of cleaners can be as high as 12 tube passes.

The experience gained from using these techniques has allowed the cleaning duration to be forecasted with confidence and cleaning to be performed on schedule. For instance, a normal crew can clean 5000 tubes during a 12-hour shift. Clearly, the number of tubes cleaned in a day can rise with an increase in crew size, limited only by there being adequate space for the crew to work effectively.

The concern is occasionally expressed that mechanical cleaners can possibly cause damage to tube surfaces. With cleaners that have been properly designed and carefully manufactured, such damage is extremely rare. Howevwe, all offline cleaning methods sometimes need assistance where the deposits have been allowed to build up and even become hard. In such cases, it may be still be necessary to acid clean, followed by cleaning with mechanical cleaners or high pressure water to remove remaining debris.

Hydrodrilling: Since the invention in 1970, the HydroDrill has been used in the refineries, petrochemical plants, pulp and paper plants, electric power plants and other process industry plants throughout the world. The HydroDrill is extremely effective on hard, tough deposits, and after drilling it is often possible to salvage heat exchangers previously thought to be useless. Hydrodrilling can also be performed on-site therefore eliminating the need for bundles to be sent off-site for cleaning treatments. Completely blocked tubes can be restored to100% of the original tube internal diameter in one pass of the HydroDrill, cleaning tubes in one pass reduces labor costs. Typical cleaning speed for a 20-foot long tube is 30-90 seconds each. Formerly compromised tubes can be cleaned and polished to 100% efficiency so that inspection can be performed.

Since the HydroDrill does not use high-pressure water or hazardous chemicals, the risk of personal injury or property damage is significantly less than other methods. Tough hardened deposits can be removed faster and at lower overall cost. For over 30 years, the HydroDrill has proven itself to be effective and aggressive cleaning method for use in process plants within many industries.

Hydro-blasting: In these applications, water is pumped to pressures ranging from 10,000 to 40,000 psi in specialized pumps, and then conveyed through high-pressure hoses to engineered lance assemblies that spray the high velocity water directly on the exchanger tube surfaces. This action is very effective at removing foulants from the tubes.

Chemical Cleaning

Chemical cleaning methods fall into two broad categories: reactive cleaning and decontamination. Reactive chemistry is used to remove inorganic, non-carbon foulants such as calcium, carbonates, oxides, phosphates and sulfates. Decontamination chemistry is applied where hydrocarbon foulants are present.

In both the cases of reactive cleaning or decontamination, chemical cleaning utilizes a combination of three cornerstones: chemistry, flow and temperature. Each of these cornerstones can determine the degree of success in removing the deposits and is the primary reason chemical cleaning often requires more planning and experience than hydroblasting.

- Reactive chemical cleaning is most often used to improve energy efficiency, especially on cooling water exchangers and utility boilers. Depending on the type of foulant, mild to strong acids are circulated throughout the system with inhibitors to remove the foulants while minimizing impact on the base materials. Care must be taken not to overexpose the tubes to the chemicals, as metal degradation can occur. After cleaning, passivation is usually performed utilizing various methods such as an application of sodium nitrite for carbon steel or an alkaline solution such as sodium carbonate, commonly referred to as soda ash, for stainless steel.
- When fouling consists of hydrocarbon deposits, decontamination chemistry is utilized to remove the deposits. These chemistries use various methods ranging from pH adjustment to surfactant packages targeted at specific hydrocarbon types.

Flow and temperature are controlled through various means as the chemicals are applied. The desired flow can be achieved through circulation, filling and soaking, foaming, or even vapor-phase application. Temperature is often controlled through direct injection of steam or the use of additional heat exchanger.

Developing an Appropriate Cleaning Procedure

The selected cleaning procedure should remove the particular deposits that are present as effectively as is possible, and will render the unit out of service for the minimum amount of time. Some other major considerations in the selection process are as follows:

<u>Removal of obstructions</u>: Many tube-cleaning methods are ineffective when there are obstructions within tubes, or when various forms of macrofouling are present. When such obstructions are found it is advisable to proceed with the cleaning regimen as planned. The selected tube cleaner must have the body and strength to remove such obstructions. Experience have shown that, if appropriate procedures are followed, properly designed cleaners should not become stuck inside tubes, unless the tube is deformed.

<u>Removal of corrosion products</u>: When heat exchangers are equipped with copper alloy tubing, copper deposits grow continuously and the thick oxide coating or corrosion product can grow to the point where it will seriously impede heat transfer. Not only will the performance of the condenser be degraded but such deposits will also increase the potential for tube failure. When a thick outer layer of porous copper oxide is allowed to develop, it disrupts the protective inner cuprous oxide film, causing the base metal to attack and causing under deposit pitting to develop. Such destructive copper oxide accumulates together with any other deposits must be removed regularly.

<u>Surface roughness</u>: Rough tube surfaces, often the result of accumulated fouling deposits, are associated with increased friction coefficients while the reduced cooling water flowrates allow deposits to accumulate faster.it has also been found that rough tube surfaces tend to pit more easily than smooth surfaces. A tube surface rendered smooth from effective cleaning can improve condenser performance through:

1. Improved heat transfer capacity and a lower water temperature rise across the heat exchanger, reducing the heat lost to the environment.
2. Increase in both flow volume and water velocity, often resulting in reduced pumping power.
3. Increased time required between cleanings, by reducing rate of re-deposition of fouling material on the tube surfaces.
4. Reduced pitting from turbulence and gas bubble implosion.
5. Longer tube life and heat exchanger life.

Preparing to Clean a Shell and Tube Heat Exchanger

It is clear by now that to ensure that all equipment that goes into processing a product works at their optimal capacity, the operators need to take the time to inspect and clean shell and tube heat exchangers. This is no easy task, especially for those with hard-to-access tubes. Not to mention the fact that taking a day or two to inspect and clean the heat exchangers will result in lost production and therefore lost revenue. It is crucial to plan meticulously to account for the downtime and to ensure that everything goes smoothly.

<u>Knowing When to Clean</u>: In sanitary industries, like food, dairy and pharmaceutical, there are often well-established protocols for the timing of heat exchanger cleaning. These cleanings are most commonly accomplished through the use of an automated CIP (clean-in-place) system that will clean and sanitize the tubing without having to disconnect the piping or exchanger parts. They are often done daily, weekly, or between batches of products.

Most companies in industrial settings can determine whether a maintenance day where machines will be offline is worthwhile by considering the hourly cost of the losses over time and the cost of fouling. Determining the right time for the loss to be minimum will tell the operators what the best cleaning intervals are.

Over the past half-century, companies have changed the way they view scheduled maintenance days. IN the past, these cleanings took place one or more times a year. Now we have equipment that is more reliable and requires fewer cleaning days – the norm now is closer to cleaning once every four to 10 years. Of course, this depends on the exchanger type and what it is being used for. Some materials that pass through the heat exchanger are less prone to fouling than the others. For this reason, it is important that operators recognize the signs of fouling and the nature of the chemicals and products they work with.

Getting Prepared: It is important to have a checklist of everything that needs to be completed on the turnaround day. This will help someone who is inexperienced or out of practice keep track of all necessary tasks. The list should include:

- Recording how the machine is operating just before you shut it down,
- Whether all the required measuring tools are at hand,
- Layout dimension for the machine and all its parts,
- Whether there is any damage that could cause harm to the product or machine later on.

It is also important to have any replaceable spare parts on hand, like gaskets, O-rings and hardware, so that any damaged or compressed parts can be replaced before the unit is reconnected and brought back online. Because the exchanger parts can be very heavy, it is also important to have a safe lifting plan with adequate clearance to remove bonnets, piping and other parts in order to gain access to the tube bundle.

How to Clean: If the company will allow taking pictures, it is a good idea to photograph everything mentioned in the notes taken throughout the day. This will help explain any damage encountered and provide reference for the notes the person performing the turnaround takes.

Mechanical cleaning is the most widely chosen method. This involves determining what kind of deposits you will be removing from the tubes. Deposits range from small amount of silt to substances that are more difficult to remove, depending on the materials that are used in the exchanger. Once this is determined, decide which cleaning method is appropriate.

Hydroblasting has also been used, though precautions to reduce risk of injury or tube damage must be taken. This method involves water pressurized to 10,000 to 25,000 psi, which is then blasted through the tubes to remove deposits.

Chemical cleaning is another preferred method, though it is a more expensive option. Chemicals that are mildly acidic will take off debris faster and more efficiently than a mechanical process. However, the tubes will still need to be cleaned of chemicals used to prevent contamination or environmental hazards.

7 Tips for Cleaning Heat Exchangers

Shutdowns due to heat exchanger failure can cost hundreds of thousands of dollars – many times the cost of performing even the most complex cleaning procedures. When performed correctly, however, heat exchanger cleaning will improve performance and save money.

1. Ultra-High-Pressure Jetting Methods: Remote and multi-lance ultra-high-pressure water jetting should be one of the first choices for every heat exchanger cleaning program because it is effective and environmentally friendly. Using nothing but water, it is possible to successfully remove deposits and scale from heat exchangers, tube bundles and surrounding systems. Using water reduces the need for specialist disposal of potentially harmful solvents and detergents. This also will help to lower the costs of cleaning and maintenance by negating the need for hazardous chemical disposal services.

   Finally, depending on the specifics of the heat exchanger, the materials used in its construction are weakened or destroyed by certain chemicals. For instance, titanium pipework – common in liquefaction plants – is vulnerable to damage caused by acidic cleaning solutions and must be cleaned with either water or some form of mechanical method like drilling.

2. Keep Cleaning on Schedule: Routine maintenance should – as the name implies – be performed according to a schedule. Depending on the specific heat exchanger in question, the correct timing of maintenance routines may be defined by the manufacturer or set by the onsite maintenance team. Cleaning according to a routine will prevent deposits and sediment from reaching damaging levels that may force a plant shutdown. Combining cleaning with inspection routines also will help ensure equipment is fully operational and meets regulatory standards.

3. Cleaning In-Situ: Robotic heat exchanger cleaning techniques now allow for maintenance to be performed without disassembly. This is a good solutions for plant operators looking to minimize downtime and associated costs.

   Some specialists only undertake cleaning on heat exchanger equipment at their own facility, but the additional downtime incurred by this methodology is unacceptable to most businesses. If the existing contractor is unable to clean the heat exchanger in-place, a second opinion from another service provider who may have an alternative cleaning method that can complete the job on-site may be justified.

4. Go 'Bare Metal': When cleaning heat exchangers, it is important to remove all deposits and sediment, taking pipework back to the bare metal. Failure to remove all fouling will not deliver the benefits expected and reduce the return on investment in maintenance.

   Choosing to go back to bare metal significantly extends the periods between cleaning cycles by effectively returning pipework and surfaces to factory-new standard. By removing all scale and build-up, plant efficiency will increase as will the return on investment in advanced cleaning services.

5. Remember External Surfaces: Tube bundles, interior pipework and shell sides are often the highest priority for cleaning because these surfaces are most likely to be affected by chemical deposits and buildups. However, the outer surfaces of heat exchanger equipment also play an important part in heat dissipation and efficient operations.

   Cleaning the outer surfaces of heat exchanger equipment also should be included as part of the regular maintenance program, not least because it helps make carrying out visual inspections much easier. Scheduling external cleaning of heat exchangers should be much easier, requiring little, if any, downtime.

6. Use the Right Tools: Polymer deposits are particularly challenging to remove, with some operators even using hammers, chisels, and chainsaws to try and clear buildups. When dealing with precision equipment, using generalized tools like these will almost certainly result in damage to equipment and wasted effort by employees.

   In almost every case, plant equipment can be cleaned with a combination of ultra-high-pressure water jetting, bandsaws and patience. The thicker the polymers become, the longer they take to clear. This further emphasizes the importance of regular, routine cleaning and maintenance.

7. Never Accept Standard Cleaning Techniques: Many industrial service providers continue to provide the same narrow array of cleaning techniques simply because "that's the way it has always been done". Standard cleaning techniques are quite effective but can fail to account for developments in heat exchanger technology that make the job more complicated.

   Worse still, standard cleaning techniques can be slower to use and have variable results, meaning that the heat exchanger may not be cleaned as thoroughly as possible. Traditional water jetting techniques fail to account for shell-side residue, meaning that as much as 50% of deposits are left behind after the cleaning operation has finished. In effect, standard cleaning techniques can only hope to improve heat exchanger performance by half.

   Advanced cleaning techniques can remove shell-side deposits from heat exchangers, further underlining the importance of not settling for the standard services. By cleaning both sides of heat exchanger, performance gains will be much higher. Far better for the heat exchanger – and ultimately profits – is to liaise with suppliers who create innovative solutions or combine proven techniques for cleaning. Newer techniques may be more effective and complete cleaning projects more quickly and efficiently than standard alternatives.

In conclusion, these seven tips will help businesses cut costs and downtime, and they can help ensure that heat exchangers are cleaned to the point that they raise profitability.

Source: The Practical Application and Innovation of Cleaning Technology for Heat Exchangers *by* George Saxon and Richard Putman

Heat Exchanger Cleaning Methods *by* Joe Davis

How to Prepare and Clean a Shell and Tube Heat Exchanger *by* Enerquip

7 Tips for Cleaning Heat Exchangers *by* Ben Lioyd

Differential Thermal Expansion

EXPANSION BELLOWS

Expansion joints are designed to provide flexibility for thermal expansion and also to function as a pressure containing element. In all pressure vessels with integral expansion joints, the hydrostatic end force caused by pressure and/ or the joint spring force shall be resisted by the adequate restraint elements (e.g., exchanger tubes or shell, external restraints, anchors etc.). The stress in these restraining elements shall not exceed the maximum allowable stress at the design temperature for the given material.

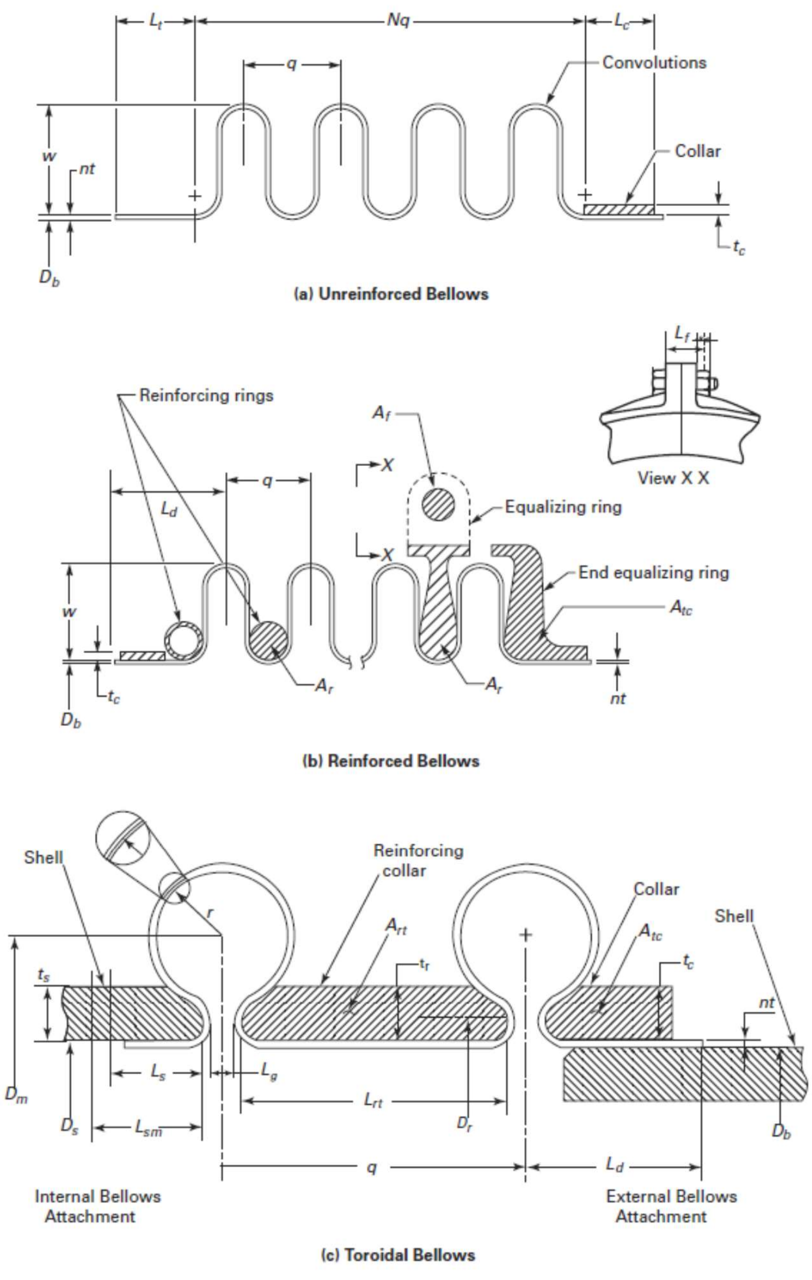


Figure 1: Typical Bellows Expansion Joints

Mandatory Appendix 26 of ASME Section VIII, Division 1 provides minimum requirements for the design of bellows expansion joints that are used an integral part of heat exchangers or other pressure vessels. Typical bellows expansion joints are shown in Figure 1. They may be subject to internal or external pressure, and cyclic displacement. The bellow may consist of single or multiple identically formed convolutions; they may be as-formed (not heat-treated), or annealed (heat-treated).

CONDITIONS OF APPLICABILITY

The design rules of Appendix 26 are applicable only when the following conditions are satisfied:

a. The bellows shall be such that $Nq \leq 3D_b$ where

   N = Number of convolutions

   q = Convolution pitch (Refer to Figure 1)

   D_b = Inside diameter of bellows convolution and end tangents

b. Bellows nominal thickness shall be such that nt ≤ 0.2 in (5.0mm) where

   n = Number of plies

   t = nominal thickness of one ply

   Ply is an individual wall thickness. Multi-ply is description of a bellows made from tubes of two or more plies.

c. The number of plies should not be more than 5.

d. The displacement shall be essentially axial. However, angular and/ or lateral deflection inherent in the fit-up of the expansion joint to the pressure vessel is permissible provided the amount is specified and is included in the expansion joint design.

e. These rules are valid for design temperatures up to temperatures shown in Table 1. Above these temperatures, the effects of time-dependent behavior (creep and creep fatigue interaction) shall be considered.

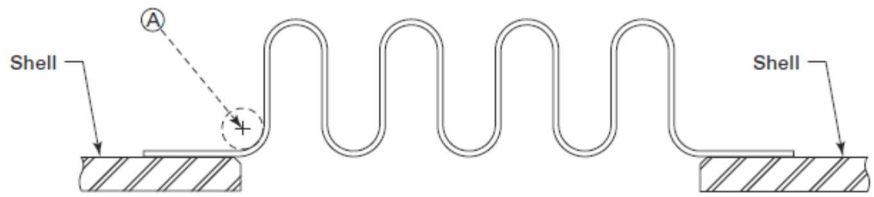
   Table 1: Maximum design temperatures

Table in which material is listed	Maximum Temperature	
	ºF	ºC
UNF-23.1	300	150
UNF-23.3	800	425
UNF-23.4	600	315
UNF-23.5	600	315
UHA-23	800	425

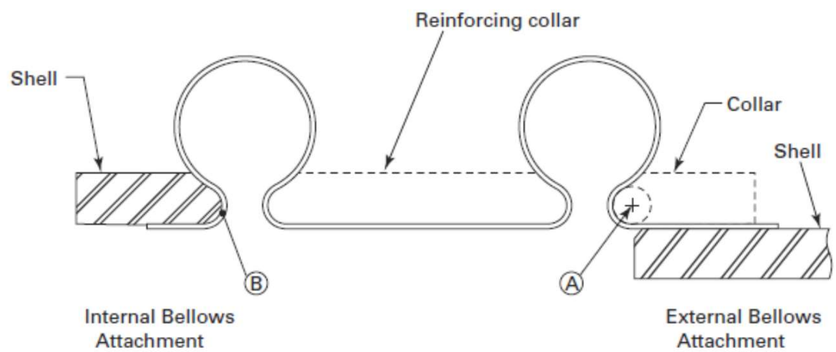
f. The length of the cylindrical shell on each side shall not be less than $1.8\sqrt{D_s t_s}$. The length shall be taken from the beginning of the end convolution [point A in Figure 2, illustration (a) and (b)], except that for internally attached toroidal bellows, the length shall be taken from the extremity of the shell [point B in Figure 2, illustration (b)].

D_s = Inside diameter of cylindrical shell, or weld end on which the bellows is attached

t_s = Nominal thickness of shell or weld end



(a) U-Shaped Bellows



(b) Toroidal Bellows

Figure 2: Starting Points for the Measurement of the Length of Shell on each side of the Bellows

DESIGN CONSIDERATIONS

General

- The expansion joints shall be provided with bars or other suitable members for maintaining the proper overall length dimension during shipment and pressure vessel fabrication.
- Expansion bellows shall not be extended, compressed, rotated, or laterally offset to accommodate connecting parts that are not properly aligned, unless the design considers such movements.
- Any torsional loads applied to the expansion joints should be kept to a minimum to prevent high shear stresses that may be detrimental to their use.
- The minimum thickness limitations specified in paragraph UG-16(b) of the code do not apply to expansion bellows.
- Expansion bellows longitudinal weld seams shall have a joint efficiency of 1.0.
- The elastic moduli, yield strength and allowable stresses shall be taken at design temperatures. However, when performing the fatigue evaluation, it is permitted to use the operating metal temperature instead of the design temperature.

Fatigue

The calculation of fatigue life may be performed by any analytical method based on the theory of elasticity. However, the method must be substantiated by correlation with proof or strain gage testing as per paragraph UG-

101 on a consistent series of the same basic design (annealed and as-formed bellows are considered as separate designs) to demonstrate predictability of rupture pressure and cyclic life. The substantiation of any analytical method shall be based on data obtained from five separate tests on bellows of the same basic design. When substantiating bellows design with more than two convolutions in series, the test data shall have been obtained from bellows with a minimum of three convolutions. When compared with the data obtained from the calculation procedure, the test data shall demonstrate that the rupture pressure of the bellows is equal to or greater than three times the maximum allowable working pressure at room temperature. The specified number of fatigue cycles shall be less than the calculated cycles to fatigue based on the data obtained from testing.

Cumulative Damage

If there are two or more types of stress cycles that produce significant stresses, their cumulative effect shall be evaluated as given below:

a. Designate the specified number of times each type of stress cycles of Type 1, 2, 3 etc. will be repeated during the life of the expansion joint as n_1, n_2, n_3 etc. respectively. In determining n_1, n_2, n_3 etc., consideration shall be given to the superposition of cycles of various origins which produce a total stress difference greater than the stress difference ranges of the individual cycles.

   For example, if one type of stress cycle produces 1,000 cycles of a stress difference variation from 0 to +60,000 psi, and the other type of stress cycle produces 10,000 cycles of stress difference variation from 0 to -50,000 psi, the two type of cycles to be considered are defined by the following parameters:

   Type 1 cycle:

   n_1 = 1,000

   S_{t1} = |60,000| + |-50,000| = 110,000 psi

   Type 2 cycle:

   n_1 = 10,000 – 1,000 = 9,000

   S_{t2} = |0| + |-50,000| = 50,000 psi

   where S_t = Total stress range due to cyclic displacement

b. For each value S_{t1}, S_{t2}, S_{t3} etc., use the applicable design fatigue curve to determine the maximum number of repetitions which would be allowable if this type of cycle were the only one acting. Call these values N_1, N_2, N_3 etc.

c. For each type of stress cycle, calculate the usage factors U_1, U_2, U_3 etc. from:

   U_1 = n_1/N_1

   U_2 = n_2/N_2

   U_3 = n_3/N_3, etc.

d. Calculate the cumulative usage factor from $U = U_1 + U_2 + U_3 \ldots$ The cumulative usage factor, U shall not exceed 1.0.

TORSION

The shear stress due to torsion shall satisfy either of the following criteria:

a. The shear stress due to torsional load, M_Z

   $\tau_Z = \frac{2|M_Z|}{\pi n t D_b^2}$ shall comply with $\tau_Z \leq 0.25S$.

b. The shear stress due to twist angle θ_Z, expressed in radians

$\tau_Z = \frac{|\theta_Z| G_b D_b}{2NL_{dt}}$ shall comply with $\tau_Z \leq 0.25S$.

where, θ_Z = Twist angle between two extreme points of the end convolutions

G_b = Modulus of rigidity of bellows material at design temperature

= $\frac{E_b}{2(1+\nu_b)}$

E_b = Modulus of elasticity of bellows material at design temperature

ν_b = Poisson's ratio of bellows material

L_{dt} = Developed length of one convolution

= A/nt_p for U-shaped bellows

A = Cross sectional metal area of one convolution

= $\left[2\pi r_m + 2\sqrt{\left\{\frac{q}{2} - 2r_m\right\}^2 + \{w - 2r_m\}^2}\right] n\, t_p$

r_m = Mean torus radius of U-shaped bellows convolution

= $r_i + (nt/2)$

r_i = Average internal torus radius of U-shaped bellows convolution

w = Convolution height

t_p = Thickness of one ply, corrected for thinning during forming

= $t\sqrt{\frac{D_b}{D_m}}$

D_m = Mean diameter of bellows convolution

= $D_b + w + nt$ for U-shaped bellows

U-SHAPED UNREINFORCED BELLOWS

Paragraph 26-6 of the code contains rules for design of bellows having unreinforced U-shaped convolutions. Each half convolution consists of a sidewall and two quarter tori of nearly the same radius (at the crest and root of convolution), in the neutral position, so that the convolution profile presents a smooth geometrical shape as shown in Figure 1.

Following conditions of applicability apply in addition to those listed at the beginning of this article:

a. A variation of 10% between the crest convolution radius r_{ic} and the root convolution radius r_{ir} is permitted.

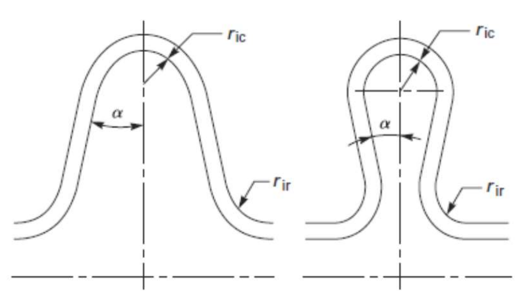


Figure 3: Possible Convolution Profile in the Neutral Position

b. The torus radius shall be such that $r_i \geq 3t$, where $r_i = \frac{r_{ic}+r_{ir}}{2}$

   A smaller torus radius may be used provided the requirements of the fatigue correlation testing (also provided in the Appendix 26) are satisfied.

c. The offset angle of sidewalls, α, in the neutral position shall be such that $-15 \leq \alpha \leq +15$ (See Figure 3).

d. The convolution height shall be such that $w \leq \frac{D_b}{3}$.

Paragraph 26-6 of the code gives equations and compliance requirements for:

- Circumferential membrane stress at the end tangent due to pressure, S_1;
- Circumferential membrane stress at the collar due to pressure, S'_1;
- Circumferential membrane stress due to pressure for end convolutions, $S_{2,E}$, and for intermediate convolutions, $S_{2,I}$; and
- Meridional membrane stress due to pressure, S_3 and meridional bending stress due to pressure, S_4.

Paragraph 26-6 of the code also gives requirements for instability due to internal pressure (that includes column instability and in-plane instability), for external pressure strength (that includes external pressure capacity and instability due to external pressure), for fatigue evaluation, and for axial stiffness.

U-SHAPED REINFORCED BELLOWS

Paragraph 26-7 of the code contains rules for design of bellows having U-shaped convolutions with rings to reinforce the bellows against internal pressure. Each half convolution consists of a sidewall and two quarter tori of the same radius (at the crest and root of convolution), in the neutral position, so that the convolution profile presents a smooth geometrical shape as shown in Figure 1.

Following conditions of applicability apply in addition to those listed at the beginning of this article:

a. A variation of 10% between the crest convolution radius r_{ic} and the root convolution radius r_{ir} is permitted.

b. The torus radius shall be such that $r_i \geq 3t$, where $r_i = \frac{r_{ic}+r_{ir}}{2}$

   A smaller torus radius may be used provided the requirements of the fatigue correlation testing (also provided in the Appendix 26) are satisfied.

c. The offset angle of sidewalls, α, in the neutral position shall be such that $-15 \leq \alpha \leq +15$ (See Figure 3).

d. The convolution height shall be such that $w \leq \frac{D_b}{3}$.

Paragraph 26-7 of the code gives equations and compliance requirements for:

- Circumferential membrane stress at the end tangent due to pressure, S_1;
- Circumferential membrane stress at the collar due to pressure, S'_1;
- Circumferential membrane stress due to pressure for bellows convolutions, S_2; and
- Meridional membrane stress due to pressure, S_3 and meridional bending stress due to pressure, S_4.

The equation for circumferential membrane stress due to pressure at the reinforcing member, and the membrane stress due to pressure for reinforcing fastener are also provided.

Paragraph 26-7 of the code also gives requirements for instability due to internal pressure (that includes column instability and in-plane instability), for external pressure strength (that includes external pressure capacity and instability due to external pressure), for fatigue evaluation, and for axial stiffness.

TOROIDAL BELLOWS

Paragraph 26-8 of the code contains rules for the design of bellows having toroidal convolutions. The bellows can be attached to the shell either externally or internally. Each convolution consists of a torus of radius r as shown in Figure 1.

Following conditions of applicability apply in addition to those listed at the beginning of this article:

a. The type of attachment to the shell (external or internal) shall be the same on both sides;

b. Distance L_g (see Figure 1) shall be less than 0.75r in the maximum extended position; and

c. For internally attached bellows, the length of the shell on each side of the bellows having thickness t_s, shall be at least equal to $L_{sm} = 1.8\sqrt{D_s\, t_s}$.

Paragraph 26-8 of the code gives equations and compliance requirements for:

- For externally attached bellows, the circumferential membrane stress at the end tangent due to pressure, S_1;
- For externally attached bellows, the circumferential membrane stress in the collar due to pressure, S_1';
- For internally attached bellows, the circumferential membrane stress in the shell due to pressure, S_1''';
- Circumferential membrane stress in the bellows convolution due to pressure, S_2;
- Meridional membrane stress in the bellows convolution due to pressure, S_3; and
- Circumferential membrane stress in the reinforcing collar due to pressure, S_2'.

Paragraph 26-8 of the code also gives requirements for instability due to internal pressure (that includes column instability and in-plane instability), for external pressure strength (that includes external pressure capacity and instability due to external pressure), for fatigue evaluation, and for axial stiffness.

BELLOWS SUBJECTED TO AXIAL, LATERAL, OR ANGULAR DISPLACEMENT

Expansion bellows are subjected to axial displacement (Figure 4), lateral displacement (Figure 5), and angular rotation (Figure 6). Readers are encouraged to refer to the paragraph 26-9 of the code for the analysis of these phenomena with the bellows.

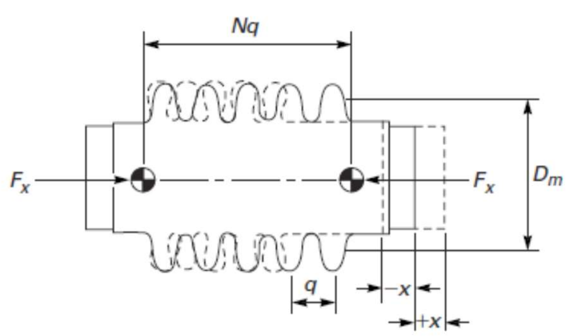


Figure 4: Bellows Subject to Axial Displacement

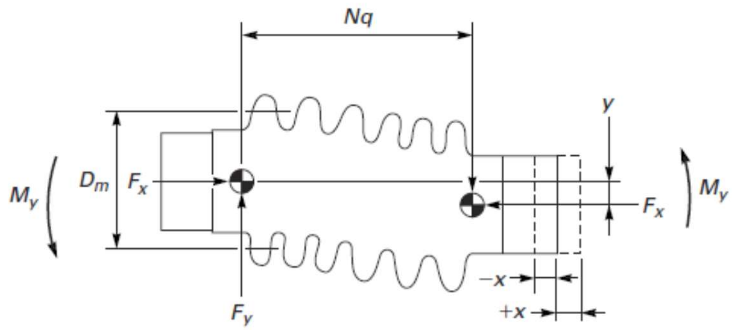


Figure 5: Bellows Subjected to Lateral Deflection

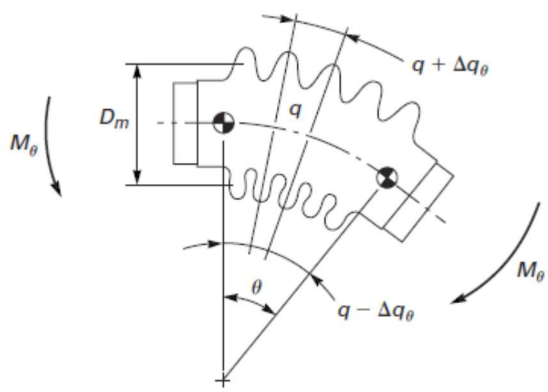


Figure 6: Bellows Subjected to Angular Rotation

Readers are also encouraged to refer to Appendix 26 of the code for the requirements relating to the fabrication, examination, pressure test requirements, and markings and reports of the expansion bellows.

Source: ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 – Appendix 26

POWER OF WORDS

According to Compton's Encyclopedia, the total number of words in the English language is around 750,000. Of that number, guess how many words we habitually use: 500 to 2,000 at the most, which represents only one half of one percent of the language. In Roget's Thesaurus there are more than 3,000 words describing various emotions. Of those, there were 1,051 words for positive emotions and 2,286 for negative emotions; roughly twice as many negative words as positive words! Think of the implications.

We have at our disposal a power that can change lives, make a sick spirit healthy, encourage success, guide those in need, make or break relationships, and create a lasting impression. That power is the power of words.

Words have incredible power in our lives. For one, they provide us with a vehicle for expressing and sharing our experiences with others. We can choose to use this power constructively with words of encouragement, or destructively using words of despair. Simply by changing our habitual vocabulary – the words we consistently use to describe the emotions of our life – we can instantly change how we think, feel and how we live.

WORDS IN ANCIENT TIMES

The ancients believed that the spoken words contained the power and authority of the Gods. In later centuries, any person who could actually write words was elevated almost to the level of the divine. Words dictated how life should be lived, what you could or couldn't do; they could be used for good or for harm. There were spells, there were prayers. The power of words was awesome.

WORDS AND ITS RESPONSIBLE USE

Considering the 'powerful force' of the words we utter, we must discipline ourselves to speak in a way that conveys respect, gentleness and humility. Before speaking, take a few moments to contemplate what you will say and how you will say it; while considering the impact they will have on the listener(s). There are certain rules that should guide all our communication with others. Always speak the truth, avoid exaggerations, be consistent in what you are saying, don't use double standards in addressing people, don't use your words to manipulate others, and most importantly do not use words to insult or belittle anyone. Intentionally negative words can lower self-esteem, kill the joy of enthusiasm and change one's attitude about life. Well-chosen positive words, on the other hand, even just one simple word can motivate and encourage dreams and bring about life changes.

CHANGING TIMES

It is not uncommon these days to characterize opponents using words that today are generally unacceptable. One such word is "retarded" – it is unacceptable no matter how it is used. It hurts others and cheapens us. Yet (although not many will admit), we all use some variation of this word in safe circles where friends excuse each other's bad taste and simply laugh it off. Similarly there are many other expressions that demean based on race and gender or mental health. Words like "cripple" would have been acceptable at one point in history (New York City's respected Hospital for Special Surgery used to be called the Hospital for the Ruptured and Crippled). It seems neutral to me as it was in common use when I was growing up. But today this word can offend people and is no longer tolerated.

GREETINGS

Most people greet each other with words that have no power. Think of the last time you heard someone else (or even yourself) respond to a greeting of "How are you?" with "Oh, I am doing so-so", "Hanging in there", or my favorite "Not too bad". It probably wasn't much past yesterday.

Try this: use words to change your situation, not to describe it. Next time anyone asks, "How are you?" whether it is someone at work or cashier at the store, respond with strength. Give them an energetic and enthusiastic "Great!" or Terrific!". It will be hard to do without a smile on your face, and you are likely to get one back. You will likely feel a physical response of increased energy. Your words will send a message to your mind that will be consistent with feeling Great! or Terrific!

To see the results, you have to do this often and with sincere enthusiasm (not robotically). When you do, your subconscious mind will begin to act on what you are saying and begin to design your reality to be consistent with your thoughts and words. Yoda from *Star Wars*, understood this when he commanded Luke Skywalker, “Do or do not. There is no try.”

POWER KILLERS AND POWER BUILDERS

Speaking with power also creates a sense of accountability and commitment to get the best from yourself and others. Your challenge is to consciously avoid using words that are power killers. These words sap energy and commitment from your interactions, and ultimately your actions.

First eliminate these words from your vocabulary:

1. I can’t
2. If
3. Doubt
4. Try
5. I don’t think
6. I don’t have the time
7. May be
8. I’m afraid of
9. I don’t believe
10. It’s impossible

Omitting these words is not enough. A sports team needs more than just a good defense to win; it also needs a powerful offense. So, mobilize your own offensive assault with the words you choose. Build positive mental connections and commitments by using these power builders:

1. I can
2. I will
3. Expect the best
4. Commit
5. I know
6. I will make the time
7. Positively
8. I am confident
9. I do believe
10. All things are possible

The power of your actions is preceded by the power of your words. Speak with power to bring out the best in yourself and others.

POWER OF WORDS IN BUSINESS

Along these parallel lines of good and bad are how we communicate in business so that we can elicit positive results. Do we use words that wedge clients away from us or use words that attract clients towards us? The power of words can shape us into a rainmaker, entrepreneur, or chief of our growing tribe. When we use words that command a positive image and situation, we will then cast that positive net farther and farther. Further, we will move out of limited beliefs and into unlimited beliefs. By expressing positive tone, eye contact, hand shake etc., we become the resource folks are thirsty for in today's world.

Customers and clients want to be lead. They want consultants that are strong. You have the power of words. Learn powerful words that move mountains in the direction you want and success is sure to follow.

THE POWER OF WORDS IS MAGICAL, SPIRITUAL AND INCREDIBLE. NOTHING IS MORE POWERFUL THAN WORDS. USE THEM WELL IN YOUR LIFE.

Source: Extracts from articles by Anthony Robbins, Dr. Hyder Zahed, Richard Cohen, Lee Colan, Jay McHugh, and Kristen Houghton.

BUILDING A BETTER TOMMORROW

It is becoming less practical for many companies to maintain in-house engineering staff. That is where we come in – whenever you need us, either for one-time projects, or for recurring engineering services. We understand the codes and standards, and can offer a range of services related to pressure vessels, tanks and heat exchangers.

Training & Development

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Pressure Vessels ● Heat Exchangers ● Tanks ● Piping
Petroleum ● Petrochemical ● Chemical ● Power ● Fertilizer