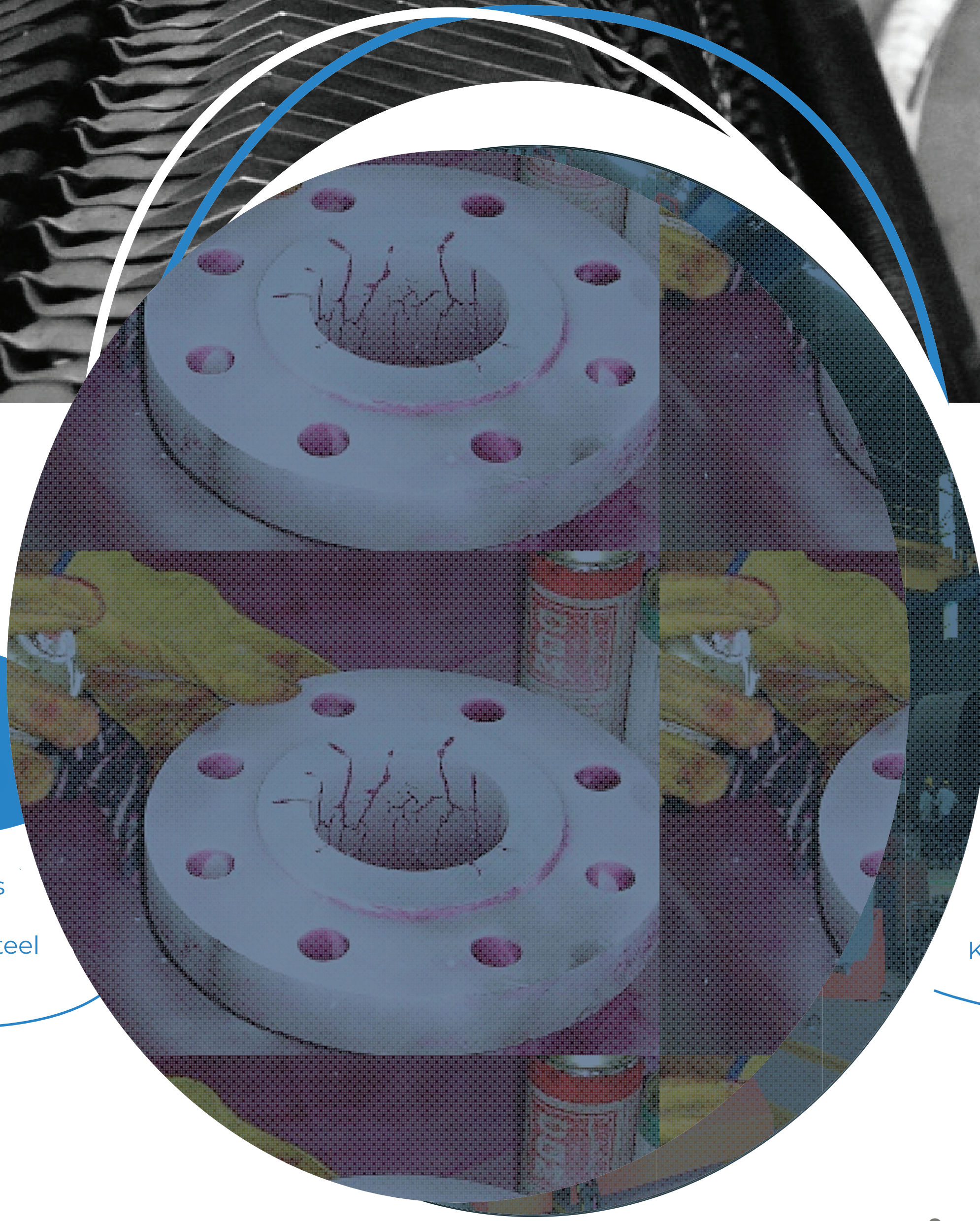
Fixed Equipment Newsletter

VOLUME 2020 , JUNE ISSUE



Nondestructive Examination of Pressure Vessels

Design Guidelines for Selection and Use of Stainless Steel

Intelligent Visual Inspections

Project Management Knowledge Areas

Serving the Fixed Equipment Community Since 2007

FOURINOX

FOURINOX is a custom fabrication company specializing in the manufacturing of ASME code pressure vessels, API certified, Atmospheric tanks, Shell & Tube Heat Exchangers for various national and international customers. At FOURINOX, we know complex projects, we've been doing since 1974.

Heat Exchangers and Vessels:

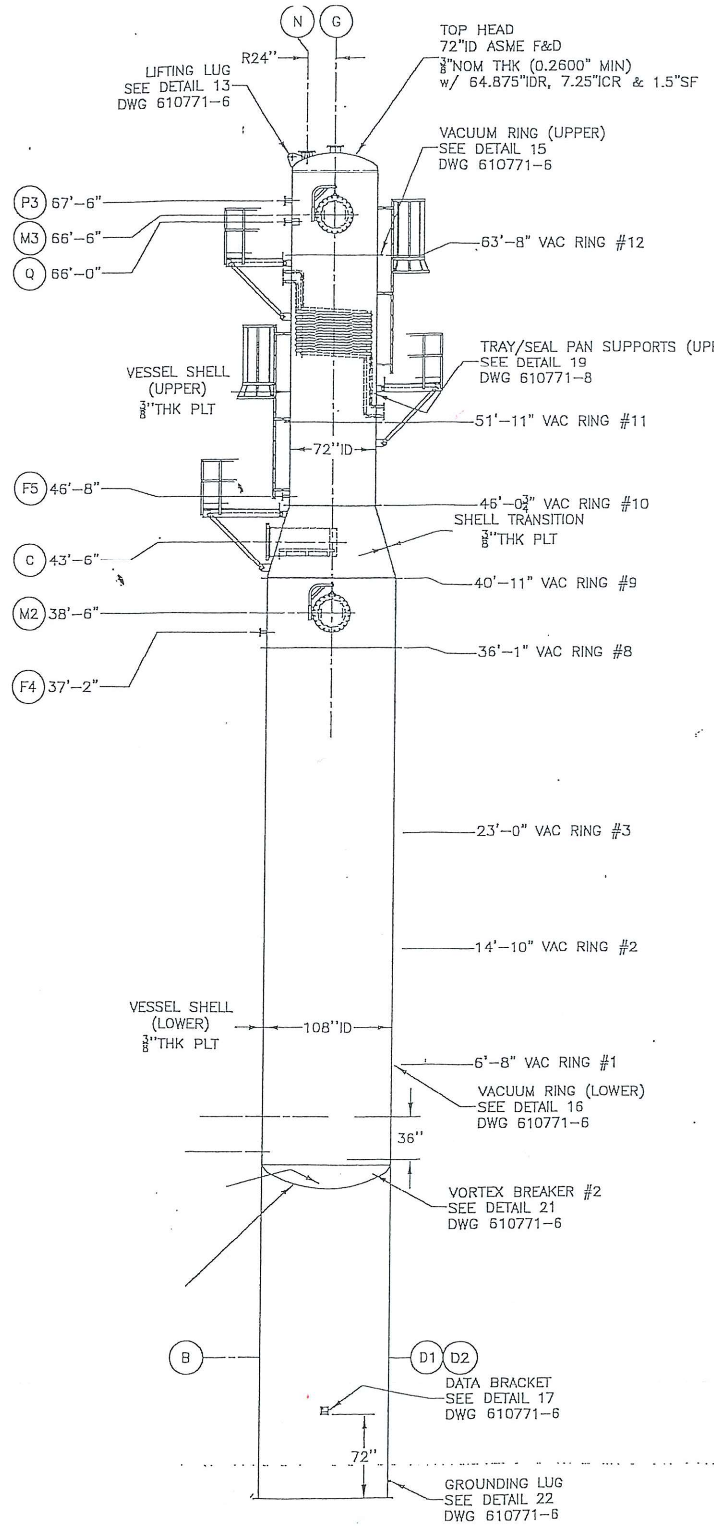
- *ASME Vessels*
- *Heat Exchangers (Shell & Tube)*
- *Columns*
- *Evaporators*
- *Reactors*
- *Jacketed Vessels*
- *API-650 Tanks*
- *Clad & Insulated Vessels*

Industries served:

- *Chemical*
- *Water Process*
- *Petro-Chem*
- *Oil & Gas*
- *Defense*

Materials:

- *Stainless 304 & 316L*
- *Duplex Stainless Grades*
- *High Alloy's*
- *C276*
- *Titanium*
- *Carbon Steel*



To hear more of our custom engineered fabrications & capabilities we invite you to Contact:

Mark Maratik
Vice President of Sales & Marketing
1015 Centennial Street / Green Bay, WI / 54304
Mobile: 920-492-9899
Email: mark.maratik@fourinox.com
Website www.fourinox.com :

COVID-19: Social Distancing and Masks

The Center for Disease Control and Prevention (CDC) in the US has long been advocating that people maintain a safe social distance of 2 meters (6 feet) from others as well as wear a mask when heading out in public. If Bill Bryson in his book "The Body: A Guide for Occupants" is to be believed, the recommended social distance of 6 feet may not be enough. Following is an excerpt from his book:

Recently, it has been discovered that sneezes are a much more drenching experience than anyone thought. A team led by Professor Lydia Bourouiba of MIT, as reported by Nature, studied sneezes more closely than anyone had ever chosen to before and found that sneeze droplets can travel up to eight meters (26 feet) and drift in suspension in air for 10 minutes before gently settling onto nearby surfaces. Through ultra-slow-motion filming, they also discovered that a sneeze isn't a bolus of droplets, as has always been thought, but more like a sheet – a kind of liquid Saran Wrap – that breaks over nearby surfaces, providing further evidence, if any were needed, that you don't want to be too close to a sneezing person. An interesting theory is that weather and temperature may influence how the droplets in a sneeze coalesce, which could explain why flu and colds are more common in cold weather, but that still doesn't explain why infectious droplets are more infectious to us when we pick them up by touch rather than when we breathe them in.

It has already been observed that the masks do help slow down the spread of infection and the excerpt above reinforces it with scientific findings. As the businesses reopen and people find themselves going back to the offices, they would do well to observe the CDC recommendations at a minimum. They would also do well to additionally a) refrain from touching their faces, b) washing their hands often with soap, and c) monitor their health very closely at all times. None of these measures by themselves will guarantee protection from the virus – but taken together, they will greatly reduce the possibility of infection. In the absence of a cure at this time, we owe it to ourselves and to those around us to follow these measures at the workplace and elsewhere when around other people.

Ramesh K Tiwari
ramesh.tiwari@codesignengg.com

NOTE: Look for Father's Day related snippets in this issue.

In this issue…

This page left intentionally blank.

NONDESTRUCTIVE EXAMINATION OF PRESSURE VESSELS

PRESSURE VESSEL TESTING OVERVIEW

Pressure vessels need to be structurally sound to maintain their internal pressure and not to allow whatever material is contained inside to leak out. Testing is intended to ensure that pressure vessel welds don't contain any flaws like punctures, cracks or loose connections that could compromise their efficacy. Two primary types of tests that are performed on pressure vessels include hydrostatic and pneumatic tests. The key difference between these two types is that hydrostatic testing uses water or another liquid as the test medium, and pneumatic testing uses a non-flammable, non-toxic gas like air or nitrogen. A concern with pneumatic testing is that, if a fracture occurs during testing for some reason, it could lead to an explosion. This makes hydrostatic testing a safer option since the volume of water does not rapidly increase when it is suddenly depressurized. However, there are situations where pneumatic testing is a viable option. Hydrostatic testing involves filling a vessel entirely with water, pressurizing it up to 1.3 times its design pressure limit and then watching for any leakage. Adding a tracer or a fluorescent dye to the water inside can make it even easier to see where there may be leaks.

NONDESCTRUCTIVE EXAMINATION METHODS

Beyond these basic types of testing, there are seven non-destructive examination (NDE) methods that are widely used to examine pressure vessel welds, and are described in the ASME BPV Code, Section V:

<u>DETECTION OF SURFACE DEFECTS</u>: [*Methods capable of detecting imperfections that are open to the surface only*]

Visual Test (VT) - Visual examination is generally used to determine such things as the surface condition of the part, alignment of the mating surfaces, shape, or evidence of leaking. In addition, visual examination is used to determine a composite material's (translucent laminate) subsurface conditions. There are different equipment required for direct, remote, or translucent visual examination; their capabilities include viewing, magnifying, identifying, measuring and/or recording observations. Equipment include mirrors, magnifying lens, lights (for illumination), telescopes, borescopes, fiber optics, cameras and other suitable instruments. The personnel performing visual examinations are required to have an annual vision test to assure natural or corrected near distance acuity.

Liquid Penetrant Testing (PT) - Liquid penetrant examination method is an effective means for detecting discontinuities which are open to the surface of nonporous metals and other materials. Typical discontinuities detectable by this method are cracks, seams, laps, cold shuts, laminations and porosity. In principle, a liquid penetrant is applied to the surface to be examined and allowed to enter discontinuities. All excess penetrant is then removed, the part is dried, and a developer is applied. The developer functions both as a blotter to absorb penetrant that has been trapped in discontinuities, and as a contrasting background to enhance the visibility of penetrant indications. The dyes in the penetrant are either color contrast (visible under white light) of fluorescent (visible under ultraviolet light).

<u>DETECTION OF SUB-SURFACE DEFECTS</u>: [*Methods capable of detecting imperfections that are either open to the surface or slightly subsurface*]

Magnetic Particle Test (MT) - The magnetic particle examination method is applied to detect cracks and other discontinuities on the surfaces of ferromagnetic materials. The sensitivity is greatest for surface discontinuities and diminishes rapidly with increasing depth of discontinuities below the surface. Typical types of discontinuities that can be detected by this method are cracks, laps, seams, cold shuts, and laminations.

In principle, this method involves magnetizing an area to be examined, and applying ferromagnetic particles (the examination's medium) to the surface. Particle patterns form on the surface where the magnetic field is forced out of the part and over discontinuities to cause a leakage field that attracts the particles. Particle patterns are usually characteristic of the type of discontinuity that is detected.

Eddy Current Testing (ET) – Eddy current testing makes use of electromagnetic induction to detect and characterize surface and subsurface flaws in conductive materials. It can also be used for thickness and conductivity measurements. In its most basic form – the single element ECT probe – a coil of conductive wire is excited with an alternating electric current. This wire coil produces an alternating magnetic field around itself. The magnetic field isolates at the same frequency as the current running through the coil. When the coil approaches a conductive material, current opposite to the ones in the coil are induced in the material – eddy current. Variations in the electrical conductivity and magnetic permeability of the test object, and the presence of defects causes a change in the eddy current and a corresponding change in phase and amplitude that can be detected by measuring the impedence changes in the coil which is a telltale sign of the presence of defects. This is the basis of standard (pancake coil) ECT. Since ECT is electrical in nature, it is limited to conductive material. There are also physical limits to generating eddy currents and depth of penetration.

The two major applications of eddy current testing are surface inspection and tubing inspections. Surface inspection is used extensively in the process industry - the technique is very sensitive and can detect tight cracks. Surface inspection can be performed both on ferromagnetic and non-ferromagnetic materials.

Tubing inspection is generally limited to non-ferromagnetic tubing and is known as conventional eddy current testing. Conventional ECT is used for inspecting steam generator tubing in nuclear plants and heat exchangers tubing in power and petrochemical industries. The technique is very sensitive to detect and size pits. Wall loss or corrosion can be detected but sizing is not accurate.

<u>DETECTION OF INTERNAL DEFECTS</u>: [*Methods capable of detecting imperfections that may be located anywhere within the examined volume*]

Radiographic Test (RT) - a nondestructive examination (NDE) technique that involves the use of either x-rays or gamma rays to view the internal structure of a component. In the process industry, RT is often used to inspect machinery, such as pressure vessels and valves, to detect for flaws. Compared to other NDE techniques, radiography has several advantages - it is highly reproducible, can be used on a variety of materials, and the data gathered can be stored for later analysis. Radiography is an effective tool that requires very little surface preparation. Moreover, many radiographic systems are portable, which allows for use in the field and at elevated positions. There are numerous types of RT techniques including conventional radiography and multiple forms digital radiographic testing. Each works slightly differently and has its own set of advantages and disadvantages.

Conventional radiography uses a sensitive film which reacts to the emitted radiation to capture an image of the part being tested. This image can then be examined for evidence of damage or flaws. The biggest limitation to this technique is that films can only be used once and they take a long time to process and interpret.

Unlike conventional radiography, digital radiography doesn't require film. Instead, it uses a digital detector to display radiographic images on a computer screen almost instantaneously. It allows for a much shorter exposure time so that the images can be interpreted more quickly. Furthermore, the digital images are much higher quality when compared to conventional radiographic images. With the ability to capture highly quality images, the technology can be utilized to identify flaws in a material, foreign objects in a system, examine weld repairs, and inspect for corrosion under insulation.

Ultrasonic Test (UT) - Ultrasonic testing uses high frequency sound waves to measure a material's thickness or detect any defects. An electronic system produces high-voltage electrical pulses, and in return, a transducer creates high-frequency ultrasonic energy, most commonly in the range from 500 KHz to 20 MHz. As the ultrasonic sound waves move through the material, if they encounter a discontinuity, the discontinuity will reflect back some of the energy. The transducer converts this reflected wave into an electrical signal, which is then shown on a display. Generally speaking, ultrasonic testing must be read in real-time since it doesn't produce a lasting record like radiography does. However, some modern UT equipment is designed with a means of recording the signals.

WELDING IMPERFECTIONS (DEFECTS) IN PRESSURE VESSEL WELDS

The following are welding imperfections that the NDE methods listed above used to detect. A brief description is provided for each of the imperfections:

1. Burn Through: These are the most common and the most serious weld defects on thin materials, particularly those that are 1/4" or less. Burn through can easily cause the failure of the welded structure. Weld through is caused by excessive amperage during the welding of the root or hot pass on butt welds, excessive root grinding which may cause hot pass to burn through, and poor welding technique.

Figure 1: Weld Burn Through

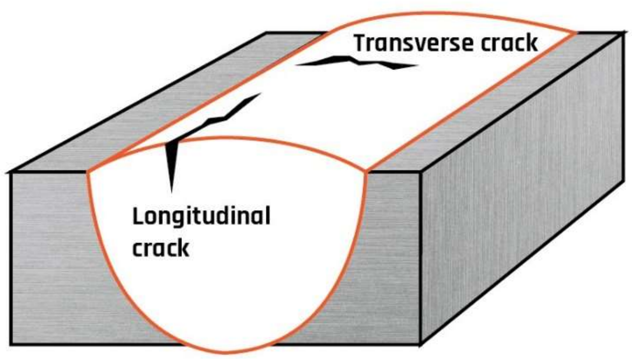


Figure 2: Weld Cracks

2. Cracks: Weld cracking refers to a depression left at the termination of a weld where the weld pool is left unfilled. Most forms of weld cracking result from the shrinkage strains that occur as the weld metal cools. If the contraction is restricted, the strains will induce residual stresses that will cause cracking. Like burn through, these are also serious weld defects because they can easily cause the failure of the welded structure. Depending on the orientation of the crack in the weld, it can be classified as longitudinal or transverse. Longitudinal when the direction is parallel to the weld and transverse when the direction is across the weld or at 90 degrees. Another type of crack is crater crack, which may be star-like in shape. This usually originates at the termination of a weld bead. Cracks are planar and can be internal or external. Cracks can have various causes depending on the type of crack. Crater cracks can be caused by incorrect

termination of the arc and high welding currents, whereas centerline cracks can be caused by excessive joint restraint, depth to width ratio of runs or incorrect consumable selection.

3. Excessive Reinforcement or Penetration: For butt welds, excess reinforcement is excess weld metal above the height of the parent metal and excess penetration is excess weld metal protruding through the root side of a weld made from one side of the joint. For fillets welds, excess reinforcement is excess weld metal above the specified fillet size including throat thickness. Excess reinforcement/penetration can be caused by excessive current, too slow travel speeds and incorrect joint fit-up.

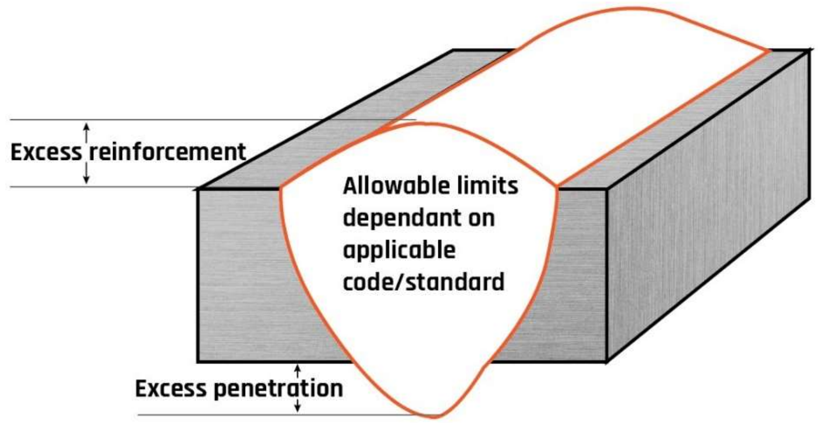


Figure 3: Excess Reinforcement and Excess Penetration

4. Inclusions (Slag/ Tungsten): An inclusion is a solid foreign matter that is entrapped during welding. It can be a metallic inclusion such as tungsten, copper or other metal or a slag inclusion which may be linear, isolated or grouped. It can also be a non-metallic inclusion such as sulphide and oxide which are a product of chemical reactions, physical effects and contamination which occurs during welding. Inclusion defects are usually internal and volumetric in nature. They are most commonly caused by incorrect welding parameters, incorrect manipulation of the electrode by the operator, incorrect inter-run cleaning or poor storage of consumables.

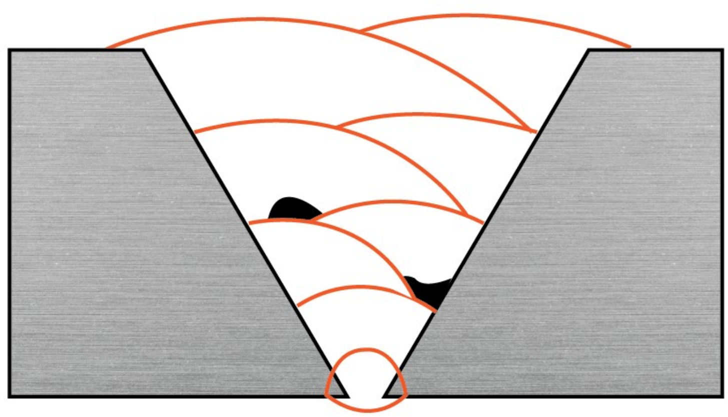


Figure 4: Internal Slag Inclusion

5. Incomplete Fusion and Incomplete Penetration: Lack of fusion is another serious weld defect which can occur as a result of;

   - A lack of fusion between the weld metal and the parent metal at the root of the weld when complete penetration is required

- A lack of sidewall fusion which occurs between weld metal and parent metal at a side weld outside of the root of the weld
- A lack of inter-run fusion which occurs between adjacent layers of weld metal on a multi-run welds

These are normally detected in welds where improper welding variables have been used and where there are improper manipulations of the electrode from the welding operator. Incorrect joint design and fit-up can also lead to lack of fusion issues.

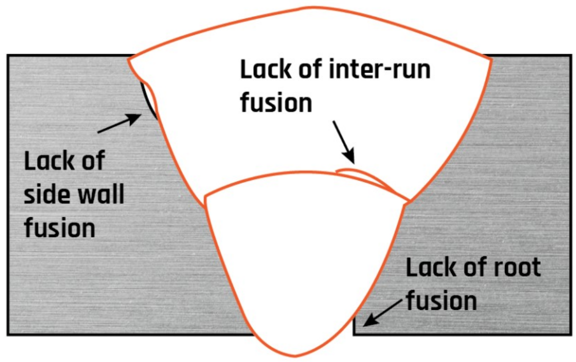


Figure 5: Incomplete Fusion

6. Misalignment: This imperfection relates to deviations from the correct position/alignment of the joint. This is primarily a result of poor component fit-up before welding, which can be compounded by variations in the shape and thickness of components (eg out of roundness of pipe). Tacks that break during welding may allow the components to move relative to one another, again resulting in misalignment.

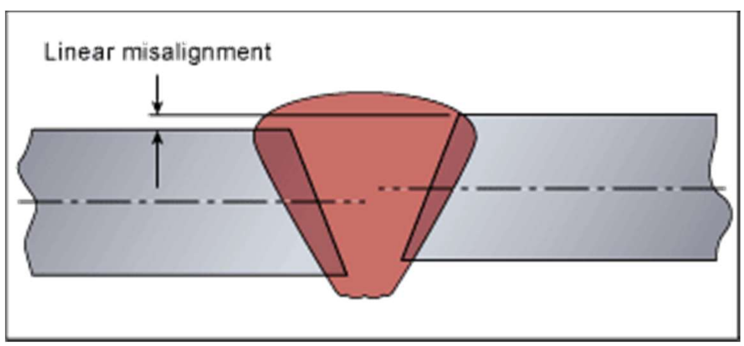


Figure 6: Linear Misalignment

7. Overlap: This is weld metal at the toe of the weld that covers the parent metal surface but has not fused to it. Generally caused by slow travel speed and wrong torch angle. This is often caused by poor manipulation of the electrode or welding gun, especially when the weld pool is large and 'cold', where the welder allows gravity to influence the weld shape before solidification. Tightly adherent oxides or scale on the metal surface can also prevent the weld metal fusing with the parent metal to cause the overlap imperfection.

8. Porosity: Porosity and other cavities such as wormholes and blowholes are caused by entrapment of gases in the weldment. These are classified as internal and volumetric defects.

   Porosity can be:

   - Linear – A line of gas pores substantially parallel to the axis of the weld

- Localised – An isolated group of gas pores
- Surface pores – A gas pore/s which breaks the surface of the weld, uniformly distributed porosity
- A number of gas pores distributed in a substantially random but uniform manner throughout the weld metal or a wormhole
- An elongated or tubular gas cavity in the weld metal
- Caused by insufficient or excessive shielding gas and contamination of the weld joint caused by oils, paints and rust

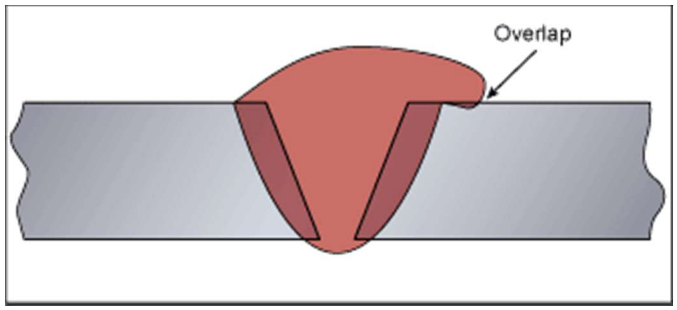


Figure 7: Overlap

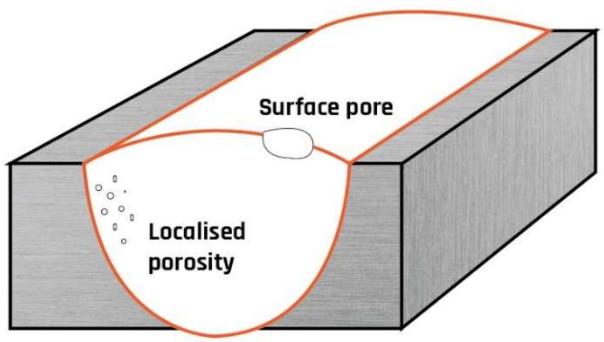


Figure 8: Porosity

9. Root Concavity: A shallow groove that may occur in the root of a butt weld. Root concavity is caused by shrinkage of the weld pool in the through-thickness direction of the weld. Melting of the root pass by the second pass can also produce root concavity. This imperfection is frequently associated with TIG welding with the most common cause being poor preparation leaving the root gap either too small or, in some cases, too large. Excessively high welding speeds make the formation of root concavity more likely.

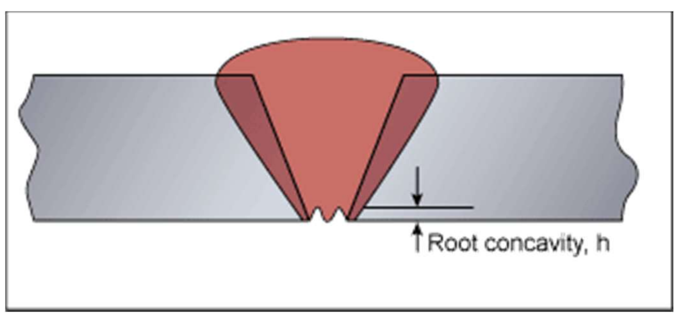


Figure 9: Root Concavity

10. Undercut: This is an irregular groove at the toe of a run in the parent metal. Figure 10 shows undercut at surface of a completed joint but it may also be found at the toes of each pass of a multi-run weld. The latter can result in slag becoming trapped in the undercut region.

When arc and gas welding, undercut is probably the most common shape imperfection. With single-sided pipe welds it may also be found at the bore surface. It may also be seen on the vertical face of fillet welds made in the horizontal vertical position.

A wide spreading arc (high arc voltage) with insufficient fill (low current or high travel speed) is the usual cause. However, welder technique, especially when weaving, and the way the welding torch is angled can both cause and be used to overcome undercutting (*ie* angled to push the weld metal to fill the melted groove). High welding current will also cause undercut - this is generally associated with the need for a high travel speed to avoid overfilling of the joint.

This imperfection may be avoided by reducing travel speed and/or the welding current and by maintaining the correct arc length.

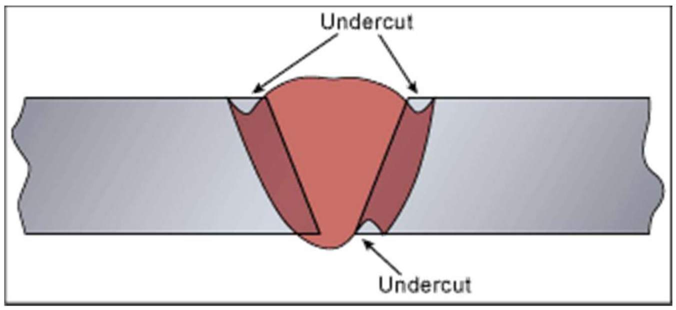


Figure 10: Undercut

IMPERFECTIONS VS TYPE OF NDE METHODS

Table 1 below lists common welding imperfections and NDE methods that are generally capable of detecting them.

Table 1: Welding Imperfections vs Type of NDE Methods

Welding Imperfections	Surface		Sub-surface		Volumetric				
	VT	PT	MT	ET	RT	UTA	UTS	AE	UTT
Burn Through	■	---	---	---	■	Δ	---	---	○
Cracks	○	■	■	Δ	Δ	■	○	■	---
Excessive/ Inadequate Reinforcements	■	---	---	---	■	Δ	○	---	○
Inclusions (Slag/ Tungsten)	---	---	Δ	Δ	■	Δ	○	○	---
Incomplete Fusion	Δ	---	Δ	Δ	Δ	■	Δ	Δ	---
Incomplete Penetration	Δ	■	■	Δ	■	■	Δ	Δ	---
Misalignment	■	---	---	---	■	Δ	---	---	---
Overlap	Δ	■	■	○	---	○	---	---	---
Porosity	■	■	○	---	■	Δ	○	○	---
Root Concavity	■	---	---	---	■	Δ	○	○	○
Undercut	■	Δ	Δ	○	■	Δ	○	○	---

Legend:

AE	-	Acoustic Emission	UTA	-	Ultrasonic Angle Beam
ET	-	Electromagnetic (Eddy Current)	UTS	-	Ultrasonic Straight Beam
MT	-	Magnetic Particle	UTT	-	Ultrasonic Thickness Measurements
PT	-	Liquid Penetrant	VT	-	Visual
RT	-	Radiography			

■ All or more standard techniques will detect this imperfection under all or most conditions.

∆ One or more standard technique(s) will detect this imperfection under certain conditions.

○ Special techniques, conditions, and/or personnel qualifications are required to detect this imperfection.

Surface methods are capable of detecting imperfections that are open to the surface only.

Sub-surface methods are capable of detecting imperfections that are either open to the surface or slightly subsurface.

Volumetric methods are capable of detecting imperfections that may be located anywhere within the examined volume.

References:

ASME Boiler and Pressure Vessel Code, Section V – 2019 Edition

Various internet sources

A Little Father's Day History

Sonora Louise Smart Dodd first brought up the idea of a father's day in 1909. She wanted a special day to honor her father, William Smart. When Sonora's mother died in childbirth with her sixth child, William was left to raise the newborn and five other children by himself on a farm in Washington State. As an adult, Sonora realized how strong and unselfish her dad had been raising his kids as a single parent.

Sonora wanted Father's Day to be celebrated on the first Sunday in June, because it was close to her dad's birthday. Instead, the first Father's Day celebration took place on June 19, 1910 in Spokane, Washington. In 1966, President Lyndon Johnson made the third Sunday of June Father's Day. It wasn't until 1972 that President Richard Nixon made Father's Day a national holiday – about 60 years after Mother's Day had been made a national holiday.

DESIGN GUIDELINES FOR SELECTION AND USE OF STAINLESS STEEL

Stainless steels are iron-base alloys containing 10.5% or more chromium. They have been used for many industrial, architectural, chemical, and consumer applications for over a half century. Currently, there are being marketed a number of stainless steels originally recognized by the American Iron and Steel Institute (AISI) as standard alloys. With so many stainless steels from which to choose from, designers should have a ready source of information on the characteristics and capabilities of these useful alloys. This article is an attempt to fill that need.

Reference is often made to stainless steel in the singular sense as if it were one material. Actually there are well over a 100 stainless steel alloys. Three general classifications are used to identify stainless steels. They are:

1) Metallurgical Structure;
2) The AISI numbering system: namely 200, 300, and 400 Series numbers; and
3) The Unified Numbering System, which was developed by American Society for Testing Materials (ASTM) and Society of Automotive Engineers (SAE) to apply to all commercial metals and alloys.

AUSTENITIC STAINLESS STEELS

Austenitic stainless steels containing chromium and nickel are identified as 300 Series types. Alloys containing chromium, nickel and manganese are identified as 200 Series types. The stainless steels in the austenitic group have different compositions and properties, but many common characteristics.

- They can be hardened by cold working, but not by heat treatment;
- In the annealed condition, all are essentially nonmagnetic, although some may become slightly magnetic by cold working;
- They have excellent corrosion resistance;
- They have unusually good formability; and
- They exhibit increase in strength as a result of cold work.

Type 304 (sometimes referred to as 18-8 stainless) is the most widely used alloy of the austenitic group. It has a nominal composition of 18% chromium and 8% nickel.

FERRITIC STAINLESS STEELS

Ferritic stainless steels are straight-chromium 400 Series types that cannot be hardened by heat treatment, and only moderately hardened by cold working. They are magnetic, have good ductility and resistance to corrosion and oxidation. Type 430 is the general-purpose stainless of the ferritic group.

MARTENSITIC STAINLESS STEELS

Martensitic stainless steels are straight-chromium 400 Series types that are hardenable by heat treatment. They are magnetic. They resist corrosion in mild environments. They have fairly good ductility, and some can be heat treated to tensile strengths exceeding 200,000 psi (1379 MPa). Type 410 is the general-purpose alloy of the martensitic group.

PRECIPITATION-HARDENING STAINLESS STEELS

Precipitation-hardening stainless steels are chromium-nickel types, some containing other alloying elements, such as copper or aluminum. They can be hardened by solution treating and aging to high strength.

DUPLEX STAINLESS STEELS

Duplex stainless steels have an annealed structure which is typically about equal parts of austenite and ferrite. Although not formally defined, it is generally accepted that the lesser phase will be at least 30% by volume. Duplex stainless steels offer several advantages over the common austenitic stainless steels. The duplex grades are highly resistant to chloride stress corrosion cracking, have excellent pitting and crevice corrosion resistance and exhibit about twice the yield strength as conventional grades. Type 329 and 2205 are typical alloys.

GUIDELINES FOR SELECTION

Stainless steels are engineering materials with good corrosion resistance, strength, and fabrication characteristics. They can readily meet a wide range of design criteria — load, service life, low maintenance, etc. Selecting the proper stainless steel essentially means weighing four elements. In order of importance, they are:

CORROSION OR HEAT RESISTANCE

This is the primary reason for specifying stainless. The specifier needs to know the nature of the environment and the degree of corrosion or heat resistance required.

MECHANICAL PROPERTIES

These include strength at room, elevated, or low temperature. Generally speaking, the combination of corrosion resistance and strength is the basis for selection.

FABRICATION OPERATIONS

How the product is to be made is a third level consideration. This includes forging, machining, forming, welding, etc.

TOTAL COST

In considering total cost, it is appropriate to consider not only material and production costs, but the life cycle cost including the cost-saving benefits of a maintenance-free product having a long life expectancy.

***We will discuss only corrosion resistance in greater detail*.**

CORROSION RESISTANCE

Chromium is the alloying element that imparts to stainless steels their corrosion resistance qualities by combining with oxygen to form a thin, invisible chromium oxide protective film on the surface. Because the passive film is such an important factor, there are precautions which must be observed in designing stainless steel equipment, manufacturing the equipment, and operation and use of the equipment, to avoid destroying or disturbing the film. In the event that the protective (passive) film is disturbed or even destroyed, it will, in the presence of oxygen in the environment, reform and continue to give maximum protection. The protective film is stable and protective in normal atmospheric or mild aqueous environments, but can be improved by higher chromium, and by molybdenum, nickel, and other alloying elements. Chromium improves film stability; molybdenum and chromium increase resistance to chloride penetration; and nickel improves film resistance in some acid environments.

MATERIAL SELECTION

Many variables characterize a corrosive environment, i.e. chemicals and their concentration, atmospheric conditions, temperature, time. So it is difficult to select which alloy to use without knowing the exact nature of the environment; however, there are guidelines:

Type 304 serves a wide range of applications. It withstands ordinary rusting in architecture, it is resistant to food processing environments (except possibly for high-temperature conditions involving high acid and chloride contents), it resists organic chemicals, dyestuffs, and a wide variety of inorganic chemicals. Type 304L (low carbon) resists nitric acid well and sulfuric acids at moderate temperature and concentrations. It is used extensively for storage of liquefied gases, equipment for use at cryogenic temperatures (304N), appliances and other consumer products, kitchen equipment, hospital equipment, transportation, and wastewater treatment.

Type 316 contains slightly more nickel than Type 304, and 2-3% molybdenum giving it better resistance to corrosion than Type 304, especially in chloride environments that tend to cause pitting. Type 316 was developed for use in sulfite pulp mills because it resists sulfuric acid compounds. Its use has been broadened, however, to handling many chemicals in the process industries.

Type 317 contains 3-4% molybdenum (higher levels are also available in this series) and more chromium than Type 316 for even better resistance to pitting and crevice corrosion.

Type 430 has lower alloy content than Type 304 and is used for highly polished trim applications in mild atmospheres. It is also used in nitric acid and food processing.

Type 410 has the lowest alloy content of the three general-purpose stainless steels and is selected for highly stressed parts needing the combination of strength and corrosion resistance, such as fasteners. Type 410 resists corrosion in mild atmospheres, steam, and many mild chemical environments.

2205 may have advantages over Type 304 and 316 since it is highly resistant to chloride stress corrosion cracking and is about twice as strong.

WHERE DIFFERENT GRADES ARE USED

Acids	
Hydrochloric acid	Stainless generally is not recommended except when solutions are very dilute and at room temperature.
"Mixed acids"	There is usually no appreciable attack on Type 304 or 316 as long as sufficient nitric acid is present.
Nitric acid	Type 304L or 430 is used.
Phosphoric acid	Type 304 is satisfactory for storing cold phosphoric acid up to 85% and for handling concentrations up to 5% in some unit processes of manufacture. Type 316 is more resistant and is generally used for storing and manufacture if the fluorine content is not too high. Type 317 is somewhat more resistant then Type 316. At concentrations up to 85%, the metal temperature should not exceed 212°F with Type 316 and slightly higher with Type 317. Oxidizing ions inhibit attack and other inhibitors such as arsenic may be added.
Sulfuric acid	Type 304 can be used at room temperature for concentrations over 80%. Type 316 can be used in contact with sulfuric acid up to 10% at temperatures up to 120°F, if the solutions are aerated; the attack is greater in airfree solutions. Type 317 may be used at temperatures as high as 150°F with up to 5% concentration. The presence of other materials may markedly change the corrosion rate. As little as 500 to 2000 ppm of cupric ions make it possible to use Type 304 in hot solutions of moderate concentration. Other additives may have the opposite effect.
Sulfurous acid	Type 304 may be subject to pitting, particularly if some sulfuric acid is present. Type 316 is usable at moderate concentrations and temperatures.
Bases	
Ammonium hydroxide, sodium hydroxide, caustic solutions	Steels in the 300 series generally have good corrosion resistance at virtually all concentrations and temperatures in weak bases, such as ammonium hydroxide. In stronger bases, such as sodium hydroxide, there may be some attack, cracking or etching in more concentrated solutions and at higher temperatures. Commercial purity caustic solutions may contain chlorides, which will accentuate any attack and may cause pitting of Type 316 as well Type 304.
Organics	
Acetic acid	Acetic acid is seldom pure in chemical plants but generally includes numerous and varied minor constituents. Type 304 is used for a wide variety of equipment including stills, base heaters, holding

	tanks, heat exchangers, pipelines, valves and pumps for concentrations up to 99% at temperatures up to about 120°F. Type 304 is also satisfactory for contact with 100% acetic acid vapors, and — if small amounts of turbidity or color pickup can be tolerated — for room temperature storage of glacial acetic acid. Types 316 and 317 have the broadest range of usefulness, especially if formic acid is also present or if solutions are unaerated. Type 316 is used for fractionating equipment, for 30 to 99% concentrations where Type 304 cannot be used, for storage vessels, pumps and process equipment handling glacial acetic acid, which would be discolored by Type 304. Type 316 is likewise applicable for parts having temperatures above 120°F, for dilute vapors and high pressures. Type 317 has somewhat greater corrosion resistance than Type 316 under severely corrosive conditions. None of the stainless steels has adequate corrosion resistance to glacial acetic acid at the boiling temperature or at superheated vapor temperatures.
Aldehydes	Type 304 is generally satisfactory.
Amines	Type 316 is usually preferred to Type 304.
Cellulose acetate	Type 304 is satisfactory for low temperatures, but Type 316 or Type 317 is needed for high temperatures.
Citric, formic acid and tartaric acids	Type 304 is generally acceptable at moderate temperatures, but Type 316 is resistant to all concentrations at temperatures up to boiling.
Esters	From the corrosion standpoint, esters are comparable with organic acids.
Fatty acids	Up at about 300°F, Type 304 is resistant to fats and fatty acids, but Type 316 is needed at 300 to 500°F and Type 317 at higher temperatures.
Paint vehicles	Type 316 may be needed if exact color and lack of contamination are important.
Phthalic anhydride	Type 316 is usually used for reactors, fractionating columns, traps, baffles, caps and piping.
Soaps	Type 304 is used for parts such as spray towers, but Type 316 may be preferred for spray nozzles and flake-drying belts to minimize off-color products.
Synthetic detergents	Type 316 is used for preheat, piping, pumps and reactors in catalytic hydrogenation of fatty acids to give salts of sulfonated high molecular alcohols.
Tall oil (pump and paper industry)	Type 304 has only limited usage in tall-oil distillation service. High-rosin-acid streams can be handled by Type 316L with a minimum molybdenum content of 2.75%. Type 316 can also be used in the more corrosive high-fatty acid streams at temperatures up to 475°F, but Type 317 will probably be required at higher temperatures.
Tar	Tar distillation equipment is almost all Type 316 because coal tar has a high chloride content; Type 304 does not have adequate resistance to pitting.
Urea	Type 316L is generally used.
Pharmaceuticals	Type 316 is usually selected for all parts in contact with the product because of its inherent corrosion resistance and greater assurance of product purity.

References:

Design Guidelines for the Selection and Use of Stainless Steel – Specialty Steel Industry of North America

INTELLIGENT VISUAL INSPECTION

Current oil market conditions are challenging over and above CoVid-19 pandemic. Reducing human contact and accepting social distancing will remain for quite some time and to prepare ourselves, we have to adopt new technologies that can save money and satisfy health regulations. Traditionally we are slow to adopt such a new technology.

When I watched a massive crane dangling a man in a man basket 120 feet below, going from transmission tower to transmission tower looking at components, I never dreamt there would be another option except a Hollywood block buster daredevil actor performing such tasks. Now when I see a UAV performing such inspection, I realize what a monumental breakthrough we accomplished! UAV gives ground-level operators a human-like eye-in-the-space.

Whether they're Drones, UFOs, UAVs (unmanned aerial vehicles), UAS (unmanned aircraft systems), sUAS (small unmanned aircraft systems), CPS (Cyber Physical System), RPA (Remote Piloted Aircraft), or RDVI (Remote Digital Visual Inspection), these aerobotic photographers are rapidly becoming a valuable industrial inspection tool. Let us call it UAV in this article.

UAVs are transforming many inspections that for years required:

- Substantial Scaffolding / Access platform Time and Costs.
- Staff Entry into confined spaces.
- Potential Shutdown of plant operations to permit inspections.
- Hazardous access of staff from a safety point of view, like working at heights.

Chief aspects of UAV Inspection are:

- Carries your eyes where you physically cannot go yourself
- Immediate access to remote locations
- Fast visual coverage of large areas
- Easily reproducible inspections for monitoring

UAV field investigations provide invaluable information to operations and maintenance functions like data acquisition/ reconnaissance during emergency situations.

Pressure Vessels, heaters and piping Inspection:

It's not only external aerial inspections (Refer a sample UAV Fig. 2) that consume lot less time using the UAVs but also for internal inspection (Refer a sample UAV Fig. 1) of heaters, boilers, tall columns with trays, visual inspection time is reduced by a quarter. Formal inspection bodies are independent organizations that have been approved by the API to conduct field and shop inspections using UAVs. There are quite a large number of reputed API certified inspectors working in the agencies who are performing such services to the industry.

Inspection Drones fitted with visual cameras and IR cameras can help in implementation of RBI (Risk Based Inspection) of Oil & Gas assets under API RP-580 as well as Fitness-For-Service Analysis under API 579-1 / ASME FFS-1. Inspection Drones which are designed for operations in closed or congested spaces can prove extremely advantageous for inspection carried out under piping API 570 Piping Inspection, API 510 Pressure Vessel Inspections and API STD 653 Tank Inspection, Repair, Alteration and Reconstruction.

Features:

Camera options: The rough range of UAV cameras today varies between 2–50Mp. Higher-resolution camera units will achieve a greater GSD (Ground Sample Distance measured in cm/ pixel), is the real-world size of a pixel in the images. Sensor sizes: 2/3”, 1”, Micro 4/3rds, APS-C, and full frame are available. Larger sensors have better light-gathering ability at the same resolutions.

Figure 1: Collision resistant UAV chiefly used indoors
(Photo courtesy- Flyability)

UAVs cameras often have low fixed aperture value (e.g., f 2.0), which places all objects a few meters away from camera for an equally sized camera sensor as compared to lower resolution.

Drone cameras offer various lens options that can cover anything between 10mm to 1200mm effective focal length. Long focal lengths usually linked with lower resolution.

Figure 2: LiDAR Drone for outdoor
(Photo courtesy DJI Zenmuse H20)

LED Lighting: User to change the direction of the light source, mimicking the way an inspector will move a flashlight around an object to understand its depth and provide three-dimensionality to it. 5000 to 12000 lumens lighting is preferred. Night vision cameras with IR laser is another feature for dark place imaging.

Stabilization with locking feature: The ability to be locked at a specific distance from an object allows the inspector to know the distance from the camera to the object being inspected at any given time. The UAV's ability to follow specific objects during inspection for their entire length—for example, to follow a metallic joint slowly from beginning to end.

Advanced UAV / sUAS uses a high definition camera that swivels 180° vertically to take shots from above or below with ease.

GPS: The unit's navigation system is powered by LiDAR (Light Detection and Ranging), which is used to both avoid collisions and navigate without a GPS connection. LiDAR is useful when used to create high resolution digital surfaces, terrain and elevation models. A lidar sensor mounted on a UAV, along with the lidar software can process images very quickly in the cloud, allowing for effective decisions to be made by stakeholders and relevant parties

Limitations:

Generally available UAVs cannot currently perform flights in atmospheric temperatures exceeding 180^0F and cannot currently fly in "no spark" zones and in high voltage installations. It is a challenge to use the UAVs under dark conditions and when it is out of sight. Unauthorized UAVs can also contribute to unsafe incidents or even for unlawful activities.

Industrial Standards and Regulations:

OSHA has published the use of Unmanned Aircraft Systems in Inspections 14 CFR Part 107, providing guidance for operating requirements, pilot certification, and device certification for UAVs..

UL 3030, the Standard for Unmanned Aircraft Systems, addresses electrical system requirements for UAVs operated by trained pilots.

ISO 21394 under TC 20/ SC16 Unmanned aircraft systems – has published three parts on Unmanned Aircraft Systems- classification, design, manufacture, operation (including maintenance) and safety management of UAS operations.

API announced the publication of its *Guide for Developing a UAS Program in the Oil and Natural Gas Industry*, which will help ensure worker and operational safety as the industry introduces drones in its operations.

ASME BPVC Section V Article 9 Visual Inspection will include UAS/ UAV and robotics inspection. This standard will be part of Section V, Non-destructive Testing of the BPVC. According to ASME, the goal of the Special Working Group is to develop, review and maintain guidelines, standards for requirements and methods for industrial plant (e.g. power, petrochemical, manufacturing, etc) inspection using safe and reliably operating unmanned aerial systems/unmanned aerial vehicles (UAS/UAVs). The committee is composed of inspection professionals from world-leading industries. ASME is also developing UAS Guide with 7 sections and one Appendix A covering Assets/ application areas; UAV platform like fixed wing or collision resistant; Environment like hazardous, wet, immersion, dirty, elevated temperature; Sensors like optical, radiography, UT, Lidar (Light Detection and Ranging), visual, infrared, electromagnetic, gas detection; Acceptance criteria.

ASME B30.32 Safety standard on Unmanned Aircraft system used in inspection, testing, maintenance and lifting operations is being published.

ASTM International's committee on unmanned aircraft systems (F38) and 3D Imaging Systems (E57) has published several standards on specifications, design, construction, QA and on batteries of small UAVs.

Public Safety Directives:

The current operating directives are listed below:

- UAV may only be operated by FAA licensed drone pilot

- UAV has to be registered for commercial flight with the FAA under part 107
- UAV has to weigh less than 55lbs upon takeoff, including attachments and payload
- Pilot must maintain visual line of sight with UAV during outdoor flights
- UAV has to fly at 100mph or less
- UAV cannot fly directly over people's heads
- Pilot cannot operate drone from a moving vehicle unless in a sparsely populated area

To my knowledge, there is no UAV currently certified for Hazardous areas in Class 1 Division 1 or Zone 2.

We would like to thank Srini JeyaKumar for contributing this article to the newsletter. Mr. JeyaKumar now works as a consultant in Calgary, Canada after retiring from Suncor Energy Inc. He keeps current in the industry development by attending committee meetings with ASME, API, ISO, CSA and APEGA. His interests include topics such as developing best business practices, electric vehicles, asset integrity management, records management, delivering powerful presentations, webinars and workshop sessions on mechanical stationary equipment, mentoring new immigrants and other similar subjects.

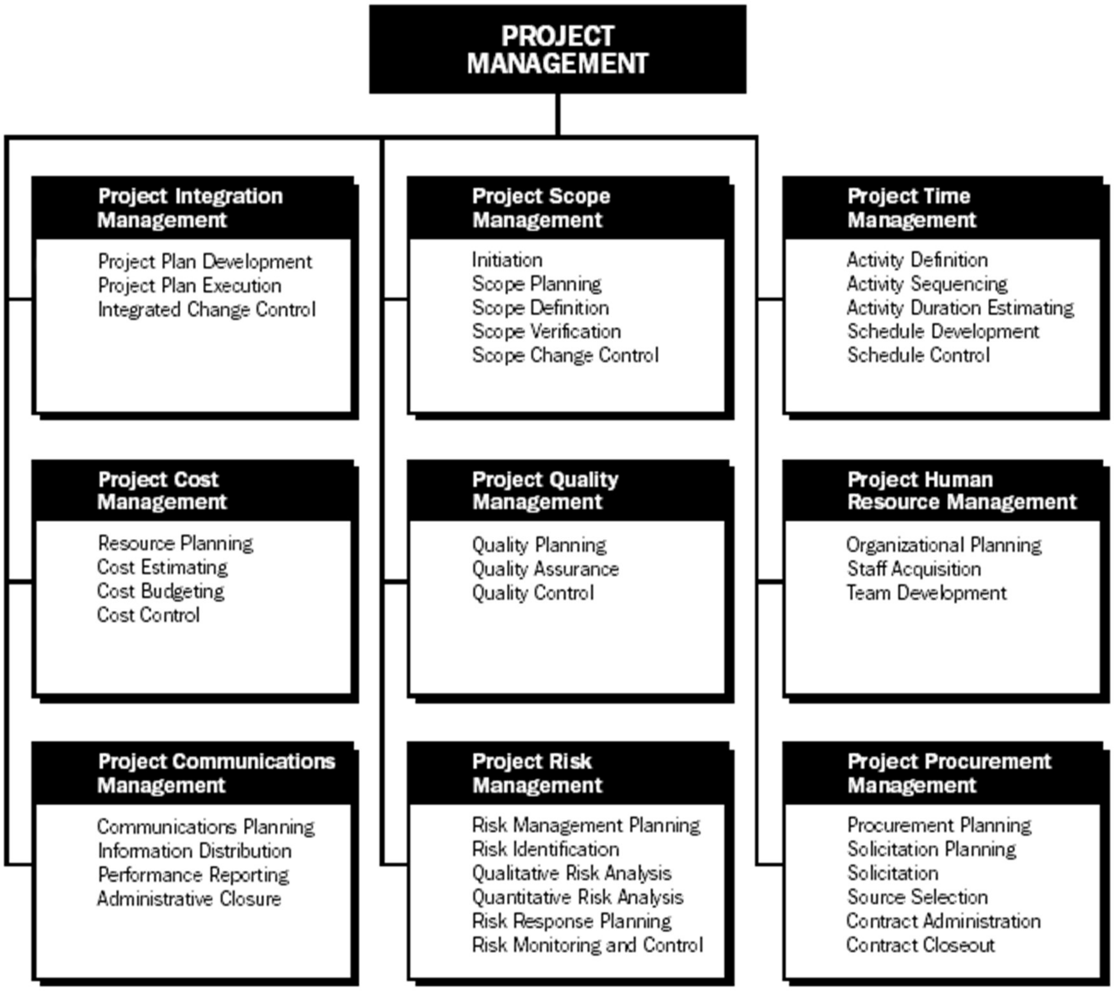
The author acknowledges the references of Flyability SA and DJI, a subsidiary of Shenzhen Dajiang Baiwang Technology Co., Ltd.

Favorite Sayings by Dads

- Go ask your mother!
- Just wait until I get you home!
- When I was you age…
- My father used to tell me…
- I used to walk to school in the snow!
- Be home early.

PROJECT MANAGEMENT KNOWLEDGE AREAS

What follows in this article is the component processes of project management as prescribed by Project Management Institute (PMI). The component processes of project management have been organized into nine knowledge areas as described below:



Project Integration Management

It describes the processes required to ensure that the various elements of the project are properly coordinated. It involves making trade-offs among competing objectives and alternatives in order to meet or exceed stakeholder needs and expectations. Major processes are:

- Project plan development – taking results of other planning processes and putting them into a consistent, coherent document.
- Project plan execution – carrying out the project plan by performing the activities included therein.
- Overall change control – coordinating changes across the entire project.

Project Scope Management

It describes the processes required to ensure that the project includes all the work required, and only the work required, to complete the project successfully. It is primarily concerned with defining and controlling what is or is not included in the project. Major processes are:

- Initiation – committing the organization to begin the next phase of the project.
- Scope planning – developing a written scope statement as the basis for future project decisions.
- Scope definition – subdividing the major project deliverables into smaller, more manageable components.
- Scope verification – formalizing acceptance of the project scope.
- Scope change control – controlling changes to the project scope.

Project Time Management

It describes the processes required to ensure timely completion of the project. Major processes are:

- Activity definition – identifying the specific activities that must be performed to produce the various project deliverables.
- Activity sequencing – identifying and documenting interactivity dependencies.
- Activity duration estimating – estimating the number of work periods which will be needed to complete individual activities.
- Schedule development – analyzing activity sequences, activity durations, and resource requirements to create the project schedule.
- Schedule control – controlling changes to the project schedule.

Project Cost Management

It describes the processes required to ensure that the project is completed within the approved budget. Major processes are:

- Resource planning – determining what resources (people, equipment, materials) and what quantities of each should be used to perform project activities.
- Cost estimating – developing an approximation (estimate) of the costs of the resources needed to complete project activities.
- Cost budgeting – allocating the overall cost estimate to individual work items.
- Cost control – controlling changes to the project budget.

Project Quality Management

It describes the processes required to ensure that the project will satisfy the needs for which it was undertaken. It includes "all activities of the overall management function that determine the quality policy, objectives and responsibilities and implements them by means such as quality planning, quality control, quality assurance and quality improvement, within the quality system. Major processes are:

- Quality planning – identifying which quality standards are relevant to the project and determining how to satisfy them.
- Quality assurance – evaluating overall project performance on a regular basis to provide confidence that the project will satisfy the relevant quality standards.

- Quality control – monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory performance.

Project Human Resource Management

It describes the processes required to make the most effective use of people involved with the project. It includes all the project stakeholders – sponsors, customers, individual contributors etc. Major processes are:

- Organizational planning – identifying, documenting, and assigning project roles, responsibilities and reporting relationships.
- Staff acquisition – getting the human resources needed assigned to and working on the project.
- Team development – developing individual and group skills to enhance project performance.

Project Communications Management

It describes the processes required to ensure timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information. It provides critical links among people, ideas and information that are necessary for success. Everyone involved in the project must be prepared to send and receive communications in the project "language" and must understand how the communications they are involved in as individuals affect the project as a whole. Major processes are:

- Communication planning – determining the information and communications needs of the stakeholders: who needs what information, when will they need it, and how it will be given to them.
- Information distribution – making needed information available to project stakeholders in a timely manner.
- Performance reporting – collecting and disseminating performance information. This includes status reporting, progress measurement, and forecasting.
- Administrative closure – generating, gathering and disseminating information to formalize phase or project completion.

Project Risk Management

It describes the processes concerned with identifying, analyzing and responding to project risk. It includes maximizing the results of positive events and minimizing the consequences of adverse events. Major processes are:

- Risk identification – determining which risks are likely to affect the project and documenting the characteristics of each.
- Risk quantification – evaluating risks and risk interactions to assess the range of possible project outcomes.
- Risk response development – defining enhancement steps for opportunities and responses to threats.
- Risk response control – responding to changes in risk over the course of the project.

Project Procurement Management

It describes the processes required to acquire goods and services from outside the performing organization. Major processes are:

- Procurement planning – determining what to procure and when.
- Solicitation planning – documenting product requirements and identifying potential sources.
- Solicitation – obtaining quotations, bids, offers, or proposals as appropriate.
- Source selection – choosing among potential sellers.

- Contract administration – managing the relationship with seller.
- Contract close-out – completion and settlement of the contract, including resolution of any open items.

References:

A Guide to Project Management Body of Knowledge - *Project Management Institute*

Driven to distraction

A young man received his first driver's license. To celebrate, he offered to take his father out for a drive. In the garage he opened the front door on the passenger's side, but his father jumped into the back seat.

"Tired of sitting in the front seat after all these years, Dad?" asked the son.

"No," said the father. "I just want to see what it's like to sit back here and kick the driver's seat over and over and over."

ADVERTISEMENT

Tailor-made

One-stop planning of biogas plants, from concept to commissioning, customised, competent, innovative and cost effective

International

Project experience with partners in biogas in more than 22 countries

References

100+ reference biogas plants from 25 Kg substrate till 200 MT per day with power and RNG generation

The engineering office Arka BRENStech is globally active in the biogas sector. Alongside the design, planning, approval planning, execution planning, preparation and involvement in the awarding of the contract, overall management of the construction site and commissioning of the biogas plants, we also offer consulting services, prepare surveys, expert reports, insurance reports, studies and plant optimisation measures, inspect technical safety equipment and provide operator services and training courses – covering the full spectrum of requirement in biogas sector.

Write to us at info@brenstech.com for more information!

www.brenstech.com

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.

- Pressure Vessels
- Heat Exchangers
- Storage Tanks
- Oil & Gas
- Petrochemical
- Chemical
- Power
- Fertilizer

Training & Development Engineering and Design Services

CoDesign Engineering