COLT ENGINEERING

Equipment Specifications

Some of the problems associated with equipment can be traced back to improper or poor specification of the equipment. Equipment purchased without a detail specification relies on the vendor to supply their standard equipment or to fabricate according to their own procedures. When this is done, the supplied equipment may not perform as required and be totally unsuitable for use in an acid plant environment.

A properly prepared equipment specification will define the performance requirements of the equipment, materials of construction, fabrication methods and procedures, test and inspection requirements, etc. Proper definition of these items will ensure that the equipment supplied will meet the performance requirements of the plant. The specification is the primary means of communicating and documenting the design, materials, fabrication, testing, etc. requirements for the equipment

If there is a problem with the equipment, the specification will be one of the primary documents that will be used to resolve the dispute.

Equipment specifications should be as short and concise as possible and still achieve the required results. Too often, specifications are lengthy documents which runs the risk that they will be ignored and that key requirements will be missed. Reference should be made to other standards and codes where possible to avoid the need to repeat sections in the specification.

Specifications should be reviewed periodically to ensure they are kept up to date. Using an old out-of-date specification can be dangerous since it may result in a piece of equipment that does not meet the requirements of the project, is unsafe, will breakdown or require excessive maintenance. Some of the areas that require review are:

- Materials – you may still see reference to the use of asbestos containing gaskets or rope.
- Vendors – reference to vendors that no longer exist or products that have been discontinued.
- Standards and Codes – ensure that the latest versions are referenced and that the standards and codes have not been discontinued.
- Incorporation of “lessons learned” and experience from the last time the specification was used or feedback from vendors.

A typical specification is divided into the following sections:

1. Scope
2. Standards, Codes and Specifications
3. Definitions and Terminology
4. Materials of Construction
5. Design Basis
6. Mechanical/Fabrication
7. Guarantees
8. Testing and Inspection
9. Documentation
10. Shipping

Scope

The scope defines the requirements of the specification and gives a brief description of the project. The scope of the specification may include any or all of the following: design, supply of material,

fabrication, shop testing, painting, delivery, erection, field services, commissioning, etc. The scope may also include a general description of the application or service in which the equipment will be placed.

Standards, Codes and Specifications

This section of the specification defines the codes and standards to be used for the design, fabrication, erection, etc. of the equipment. The applicable codes and standards to be used will depend on the location of the plant which will define the laws, rules and regulations to be used. A paragraph such as the following is usually incorporated into the specification.

The design of the plant shall comply with all codes and standards stated in this and attached specifications and all country, state and local laws, codes, standards and regulations.

The last part is a catch-all which requires the bidder to conform to all requirements whether they are stated in the specification or not. The onus is placed on the bidder to become familiar with all requirements. In practical terms, the bidder is usually not fully aware of all requirements unless they have recently performed work in the same area. Therefore, the bidder assumes the risk that there may be some requirement that they are not aware of that may significantly affect the design, cost or project schedule. The effect of not knowing all the requirements also affects the purchaser since there may be unexpected delays or costs. It is generally best for the specification to state all pertinent and applicable codes, standards or regulations that the owner is aware of that may affect the equipment.

Another paragraph that generally appears in this section refers to which edition of a particular code or standard is applicable to the project. In general, the latest edition at the time the project is awarded is applicable. If a new edition of a code or standard is issued during the course of the project, it generally will not be applicable since it was not available at the time the project was bid and there may be cost implications associated with the new requirements.

Whenever reference is made to a code or standard, it shall be understood that the latest edition as of the date of contract award shall govern.

The following paragraphs clarify the procedure to be taken if there is a conflict between the requirements of the specification and the code or standard or between various codes and standards specified.

In the event of conflicts between this specification and other documents, the most stringent code or standard shall apply.

or

In the event of conflicts between this specification and other documents, the following order of precedence shall govern.

a) Contract
b) This Specification
c) Other referenced codes, standards and specifications

or

In the event of conflicts between this specification and the applicable codes and/or standards, the Owner shall be notified promptly in writing to request a ruling or interpretation. The Bidder is not at liberty to assume which instruction shall govern.

The first paragraph provides a means of resolving conflicts and leaves it up to the bidder to resolve these conflicts. Adherence to the specification is monitored by the owner through the review of documents, inspection of equipment, etc. The second paragraph provides guidance as to the priority of the documentation rather than which requirement is more stringent. The third paragraph assumes that the owner has sufficient resources and knowledge to resolve conflicts in the specification. If the owner chooses not to be that technically involved in the project the first paragraph is more suitable.

Specific codes or standards should also be stated in this section such as the requirements to follow ASME, DIN, OSHA, etc.

Association/Organization		**Application**
AGMA	American Gear Manufacturers Association	Blowers
AFBMA	Anti-Friction Bearing Manufacturers Association	Rotating Equipment
AMCA	Air Movement & Control Association International, Inc.	Fans, Blowers
ANSI	American National Standards Institute	Materials, Piping
API	American Petroleum Institute	Fabricated Equipment, Testing and Inspection
ASME	American Society of Mechanical Engineers	Pressure Vessels, Fabricated Equipment, Testing and Inspection, Welding
ASTM	American Society for Testing and Materials	Materials
AWS	American Welding Society	Welding, Fabrication
CSA	Canadian Standards Association	Materials
DIN	Deutsche Institut fur Normung	Materials
IEC	International Electro-Technical Commission	Electrical
IEEE	Institute of Electrical and Electronics Engineers	Electrical
ISA	The Instrumentation, Systems and Automation Society (Instrument Society of America)	Instrumentation, Automation
ISO	International Standards Organization	Materials
NACE	National Association of Corrosion Engineers	Fabrication, Equipment Design
NEMA	National Electrical Manufacturers Association	Electrical
OSHA	Occupational Safety and Health Administration	Health and Safety
SSPC	Steel Structures Painting Council (The Society for Protective Coatings)	Surface Preparation, Coatings
UBC	Uniform Building Code	Civil/Structural, Foundations, Buildings

Codes and standards that are referenced in the specification should be periodically checked to ensure that the latest standard is being referenced and that the standard has not been withdrawn. Standards are continually being updated and revised so it is important to be aware of the changes since they may affect the design of equipment, inspection requirements, costs, etc.

There is a danger in specifying a standard without being familiar with its contents. Questions may come up which require detailed knowledge of the standard to answer. As a minimum, you should at least have a copy of the standard available for reference.

Definitions and Terminology

The terminology used in the specification must be selected with care since words can be interpreted in different ways. Some specifications have sections that provide definitions for words used in the specification to avoid misinterpretations and confusion. Specifications provide a means of communicating the purchaser's requirements for a piece of equipment. Terms such as '*shall*', '*should*' and '*may*' must be used appropriately to avoid confusion as to what requirements are mandatory, recommended or optional. The usual definition of these terms are as follows:

Shall indicates requirements that are mandatory.

Should indicates requirements that are recommended but not mandatory.

May indicates requirements that are optional and, consequently, are at the discretion of the designer.

Materials of Construction

The materials that will be used for the fabrication of the equipment need to be specified clearly so that the equipment performs properly from a mechanical and corrosion point of view. Reference to the appropriate material specification as provided in such standards as ASTM, DIN, etc. is generally made to clearly define the material requirements.

Some of the common standards that are used for material specification are provided in Table 1.

Table 1 – Common Standards Used to Specify Materials of Construction

Material	Standard	
Carbon Steel Plate	ASTM A516	Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service
Stainless Steel Plate	ASTM A240	Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications
Structural Steel	ASTM A36	Standard Specification for Carbon Structural Steel
Pipe	ASTM A106	Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
	ASTM A312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
Pipe Fittings	ASTM A105	Standard Specification for Carbon Steel Forgings for Piping Applications
	ASTM A182	Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
	ASTM A234	Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
	ASTM A403	Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
Flanges	ASTM A181	Standard Specification for Carbon Steel Forgings, for General-Purpose Piping
	ASTM A182	Standard Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
Bolts	ASTM A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications

Material	Standard	
Nuts	ASTM A194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both
Acid Resistant Brick	ASTM C279	Standard Specification for Chemical-Resistant Masonary Units

If the standard does not provide sufficient definition of the material requirements, the writer should clearly specify the requirements. For example, stainless steel converters are constructed from ASTM A240 Type 304 stainless steel. ASTM A240 allows for carbon contents up to a maximum of 0.08% in type 304 SS. However, the carbon content should be in the range of 0.04 to 0.08%. Type 304H SS can be used but its carbon content can range from 0.04 to 0.10%.

Design Basis

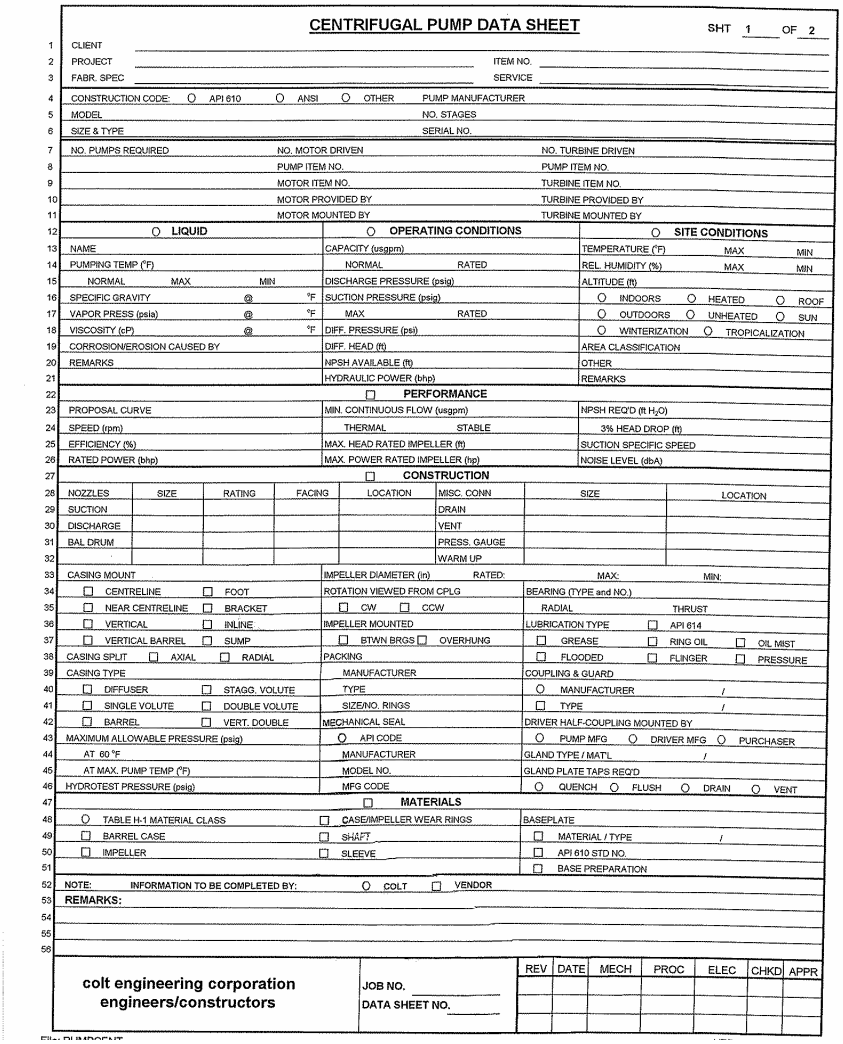
The design basis for a piece of equipment needs to be specified in detail so the vendor has sufficient information to design or size the equipment.

- Process conditions (i.e. flows, temperature, concentrations, pressures, etc.)
- Site conditions (i.e. ambient temperatures, barometric pressure, seismic zone, precipitation, etc.)
- Continuous or intermittent operation
- Noise limitations
- Utilities (i.e. steam, compressed air, water, cooling water, fuel, etc.)
- Dimensions

Equipment datasheets are often the best way to convey design information to the vendor. Datasheets provide a standard means of compiling information and data (Figure 1). Datasheets are essentially fill in the blank forms which act as a prompt or reminder of the information required.

Mechanical/Fabrication

Specific mechanical and fabrication details or procedures should be specified if required to ensure the quality of the equipment being supplied. Often a lot of general ‘motherhood’ statements are made which state the obvious. For example, flanges are generally installed with bolt holes straddling the vessel centre lines and it would seem unnecessary to have to state this in a specification. If a vessel was ever fabricated with bolt holes not straddling the centre line, it would bring into question the ability of the fabricator to perform quality work. Typically, the unusual conditions or design requirements are the ones that should be stated in the specification but many specifications still include these motherhood statements.



CENTRIFUGAL PUMP DATA SHEET — SHT 1 OF 2

CLIENT
PROJECT — ITEM NO.
FABR. SPEC — SERVICE

CONSTRUCTION CODE: ○ API 610 ○ ANSI ○ OTHER — PUMP MANUFACTURER
MODEL — NO. STAGES
SIZE & TYPE — SERIAL NO.

NO. PUMPS REQUIRED	NO. MOTOR DRIVEN	NO. TURBINE DRIVEN
	PUMP ITEM NO.	PUMP ITEM NO.
	MOTOR ITEM NO.	TURBINE ITEM NO.
	MOTOR PROVIDED BY	TURBINE PROVIDED BY
	MOTOR MOUNTED BY	TURBINE MOUNTED BY

○ LIQUID	○ OPERATING CONDITIONS	○ SITE CONDITIONS
NAME	CAPACITY (usgpm)	TEMPERATURE (°F) MAX MIN
PUMPING TEMP (°F)	NORMAL RATED	REL. HUMIDITY (%) MAX MIN
NORMAL MAX MIN	DISCHARGE PRESSURE (psig)	ALTITUDE (ft)
SPECIFIC GRAVITY @ °F	SUCTION PRESSURE (psig)	○ INDOORS ○ HEATED ○ ROOF
VAPOR PRESS (psia) @ °F	MAX RATED	○ OUTDOORS ○ UNHEATED ○ SUN
VISCOSITY (cP) @ °F	DIFF. PRESSURE (psi)	○ WINTERIZATION ○ TROPICALIZATION
CORROSION/EROSION CAUSED BY	DIFF. HEAD (ft)	AREA CLASSIFICATION
REMARKS	NPSH AVAILABLE (ft)	OTHER
	HYDRAULIC POWER (bhp)	REMARKS

☐ PERFORMANCE

PROPOSAL CURVE	MIN. CONTINUOUS FLOW (usgpm)	NPSH REQ'D (ft H_2O)
SPEED (rpm)	THERMAL STABLE	3% HEAD DROP (ft)
EFFICIENCY (%)	MAX. HEAD RATED IMPELLER (ft)	SUCTION SPECIFIC SPEED
RATED POWER (bhp)	MAX. POWER RATED IMPELLER (hp)	NOISE LEVEL (dbA)

☐ CONSTRUCTION

NOZZLES	SIZE	RATING	FACING	LOCATION	MISC. CONN	SIZE	LOCATION
SUCTION					DRAIN		
DISCHARGE					VENT		
BAL DRUM					PRESS. GAUGE		
					WARM UP		

CASING MOUNT	IMPELLER DIAMETER (in) RATED:	MAX: MIN:
☐ CENTRELINE ☐ FOOT	ROTATION VIEWED FROM CPLG	BEARING (TYPE and NO.)
☐ NEAR CENTRELINE ☐ BRACKET	☐ CW ☐ CCW	RADIAL THRUST
☐ VERTICAL ☐ INLINE	IMPELLER MOUNTED	LUBRICATION TYPE ☐ API 614
☐ VERTICAL BARREL ☐ SUMP	☐ BTWN BRGS ☐ OVERHUNG	☐ GREASE ☐ RING OIL ☐ OIL MIST
CASING SPLIT ☐ AXIAL ☐ RADIAL	PACKING	☐ FLOODED ☐ FLINGER ☐ PRESSURE
CASING TYPE	MANUFACTURER	COUPLING & GUARD
☐ DIFFUSER ☐ STAGG. VOLUTE	TYPE	○ MANUFACTURER /
☐ SINGLE VOLUTE ☐ DOUBLE VOLUTE	SIZE/NO. RINGS	☐ TYPE /
☐ BARREL ☐ VERT. DOUBLE	MECHANICAL SEAL	DRIVER HALF-COUPLING MOUNTED BY
MAXIMUM ALLOWABLE PRESSURE (psig)	○ API CODE	○ PUMP MFG ○ DRIVER MFG ○ PURCHASER
AT 60 °F	MANUFACTURER	GLAND TYPE / MATL /
AT MAX. PUMP TEMP (°F)	MODEL NO.	GLAND PLATE TAPS REQ'D
HYDROTEST PRESSURE (psig)	MFG CODE	○ QUENCH ○ FLUSH ○ DRAIN ○ VENT

☐ MATERIALS

○ TABLE H-1 MATERIAL CLASS	☐ CASE/IMPELLER WEAR RINGS	BASEPLATE
☐ BARREL CASE	☐ SHAFT	☐ MATERIAL / TYPE /
☐ IMPELLER	☐ SLEEVE	☐ API 610 STD NO.
		☐ BASE PREPARATION

NOTE: INFORMATION TO BE COMPLETED BY: ○ COLT ☐ VENDOR

REMARKS:

colt engineering corporation engineers/constructors	JOB NO. DATA SHEET NO.	REV	DATE	MECH	PROC	ELEC	CHKD	APPR

Figure 1 – Typical Engineering Datasheet

Vessel Fabrication

Most of the equipment in an acid plant is fabricated in the shop or in the field. Specifying the requirements for fabrication of the vessel will ensure that the equipment will be of the highest quality possible. Fabrication requirements that are often specified are:

- Vertical joints in plates of adjoining courses are to be a minimum of 610 mm (24 in.) apart.
- The layout of seams shall be such that longitudinal seams are not behind any obstruction that prevents inspection of the welds.
- Nozzles and manholes shall not be located in any seams.
- Circumferential seams shall be located so they do not fall within 40 mm (1.5 in.) of an internal ring.
- All sharp edges and burrs shall be removed.

The fabrication of stainless steel vessels requires special care to avoid iron contamination of the stainless steel material. A fabrication specification for stainless steel equipment may include requirements such as:

- Due to the carbon steel items included in the scope of work, the fabricator is to ensure that the stainless steel does not become contaminated with carbon steel.
- Wire brushes used on stainless steel shall be stainless steel only; any wire brush that has been used on carbon steel shall not be allowed in the stainless steel portion of the shop.

Requirements for Lined Vessels

If a vessel is to be lined, there are special fabrication requirements for the shell of the vessel to ensure that there will be no problems when the lining is installed. Some of the requirements are:

- Convex corners shall be ground to a minimum radius of 6 mm (1/4 inch).
- Concave corner shall be ground to a minimum radius of 10 mm (3/8 inch).
  All interior weld seams over which the lining is to be applied shall be ground flush.
- The shell must be circular. The maximum allowable out of roundness is 0.4% of the radius (radius < 3750 mm). For vessel diameters greater than 7500 mm, the maximum allowable out of roundness is ±15 mm (0.59 inch).
- Misalignment of shell plates at joints is not to exceed 3 mm (1/8 inch) of 10% of the plate thickness, whichever is less.

Welding

Welding requirements are generally stated in the specification particularly if welding involves dissimilar metals or materials that are difficult to weld. Welding is a specialty field and any special welding requirements that are included in the specification should be prepared by a qualified person knowledgeable in the field. Some of the general requirements for welding are:

- All welding procedures and welders are to be qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.
- All welding is to be continuous unless noted otherwise.
- All welding shall be free of visible imperfections such as cracks, excessive undercuts, surface slag inclusions, etc.
- In assembling and joining parts, the procedure and sequence shall minimize distortion and shrinkage.

Guarantees

The specification and purchase of equipment generally includes for some form of guarantee of quality or performance. Any mechanical equipment should be guaranteed against defective design, material, workmanship, etc. for the period of time specified in the purchase order agreement.

Equipment such as heat exchangers can be guaranteed such things as thermal performance and pressure drop.

For rotating equipment the guarantees are generally related to the performance of the equipment including capacity, discharge conditions, power consumption, utility consumption, etc. Specific operating points are often specified which the equipment is expected to meet.

Testing and Inspection

Testing and inspection of the equipment is required to ensure that the equipment will meet its design intent. The requirement for testing and inspection increases the cost of the equipment and extends the fabrication schedule. Despite these negatives, testing and inspection are an essential part of the fabrication process.

The purchaser generally requires the vendor to submit an Inspection and Test Plan (ITP) which is reviewed and approved prior to start of fabrication. Key points in the fabrication process can be identified as hold points that require approval from the purchaser before further fabrication can proceed. The hold point will generally involve inspection and testing of the equipment. Acceptance of a successful test may also be a requirement before further fabrication can occur.

The vendor is obligated to notify the purchaser in advance of a scheduled test and inspection so that the purchaser can attend and witness the procedure.

The purchaser should have the right to review the ITP and to conduct additional tests and inspections necessary to ensure compliance with the provision of the fabrication specification. It is important the purchaser be given free access to the areas in the fabrication shop where the work is being performed in order to carryout the required tests and inspections.

The vendor must keep all documentation up to date. Mill test certificates indicating the material specification should be available for review to ensure that the materials being used for fabrication meet the requirements of the specification.

The type and extent of testing can be specified according to the purchaser's requirements and standards. The applicable codes or standards for the type of test should be specified so the vendor understands the requirements for the test.

Radiography

Radiography is generally used to examine the quality of the welds used to fabricate the equipment. For non-pressure vessel acid plant equipment, a total of five percent of all vessel welds should be spot radiographed and examined. The method and location of welds to be tested should be in accordance with the details as outlined in Section 5 of API Standard 620, or similar code. Welds examined by radiography should be interpreted according to the standards of Paragraph UW-51 of the ASME Boiler and Pressure Code, Section VIII, Division I, or similar code.

Acid Storage Tanks

To ensure high fabrication standards and the integrity of the finished tank, the radiograph requirements for an acid storage tank are generally higher than for other equipment in the acid plant. The following radiograph requirements are typically:

- All vertical welds in all courses
- All T-joints
- All radial welds on annular ring and bridge plates
- All T-joints on double butt welded floors

- Spot radiograph of horizontal welds between shell courses
- 5% of all floor welds

Radiograph requirements will vary with the designer as a function of quality requirements and cost.

Dye Penetrant

Dye penetrant testing should be performed in accordance the applicable requirements of Section V of the ASME Code. Examination and acceptance of test results should be in accordance with Appendix 8 of ASME Boiler and Pressure Vessel Code Section VIII, Division I, or similar code. Key welds that should be subject to a dye penetrant test are:

- One hundred percent (100%) of all welds between dissimilar materials (i.e. carbon steel and stainless steel).
- All welds at the junction of the vessel sidewall and baseplate on flat bottomed vessels.
- All welds in the floor of dished bottom towers and all welds in the floor of any flat bottomed vessels.
- All interior welds on pump tanks except for welds on the roof of vertical tanks.
- All welds in the bottom sidewall from the junction of the baseplate up to 450 mm (18 inches) above the highest acid level shown on the vessel drawing.
- All welds falling under reinforcing pads.

The requirements for dye penetrant testing may vary between different pieces of equipment.

Hydrostatic Test

A hydrostatic test is required for all pressure vessels in accordance with the applicable codes (i.e. ASME). The requirement for a hydrostatic test may extend to other pressure containing equipment such as pump or blower casings. Piping will also be hydrotested according the applicable codes.

Stainless steel equipment and piping that will be hydrotested will need to be done using water containing low chloride levels to prevent stress corrosion cracking.

Rotating Equipment

The test requirements for rotating equipment like pumps, fans and blowers will be different than fabricated equipment. Testing requirements may include the following:

- Hydrostatic test of casing
- Mechanical running test
- Overspeed test
- Noise level test
- Performance test

Documentation

Equipment purchased from a vendor should come with a set of documentation which allows the purchaser to operate and maintain the equipment. The documentation should also include test and inspection reports/records that allow the purchaser to verify that the equipment has been supplied according the quality and fabrication requirements of the specification.

A complete document package may include the following:

- Completed inspection and test reports
- As built drawings
- Operating and maintenance manuals
- Weld procedures, qualifications weld maps
- Radiographs
- Material certificates

It is assumed that documentation will be supplied in a language that you understand, however, it is usually a good idea to specify the language requirements particularly if the equipment is being supplied from overseas or is being delivered to a foreign location. There may be a request that all documents be translated which can incur considerable cost. The number of copies of the documentation required to be submitted should also be specified.

Shipping

After completion of the equipment in the fabricator's facilities it must be prepared for shipment. The requirements for shipment will depend on the specifics of the equipment (i.e. size, shape, weight, etc.), the destination, mode of transport, expected storage time and environmental conditions at the site. There are generally two levels of shipment preparation specified; domestic and overseas. The difference between these two levels is primarily in the level of protection required against the elements, documentation and markings.

Some general requirements for shipping are:

- The equipment should be cleaned internally and externally of dirt, grease, scale, weld splatter and any other foreign substance.
- All nozzles and flanged connections should be covered and protected against damage during transit and installation.
- Adequate crating, skidding, strapping, etc. should be provided to prevent damage to equipment during shipping and handling.
- Machined surfaces and all threads should be coated with a heavy rust preventative grease.
- Couplings on rotating equipment should be disconnected for shipment.