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Pressure Vessel Newsletter

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A To Z of Pressure Vessels - Part 1

This article is first in a series of articles that will address the fabrication of pressure vessels under the title "A to Z of Pressure Vessels".

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Introduction

Pressure vessels are manufactured all over the world under various international standards. These standards specify the requirements to be met during the manufacture of pressure vessels; however, the means used to meet the requirements are not specified in any of these standards. In this article, a methodology to check each essential parameter specified in the relevant standards is established. Even though attempt is made based on ASME Section VIII, Division 1, the same methodology could also be extended to pressure vessels manufactured under different standards.

What is a pressure vessel?

A vessel used for the containment of pressure (either internal or external) is a pressure vessel (Figure 1).

The most commonly used standard in the manufacture of pressure vessels is ASME Section VIII, Division 1. Some other standards that are used are as follows:

1. ASME Section VIII, Division 2: Alternative Rules for Construction of Unfired Pressure Vessels
2. ASME Section VIII, Division 3: Alternative Rules for Construction of High Pressure Vessels
3. BS 5500: Specification for Unfired Fusion Welded Pressure Vessels
4. AD Merkblatter Technical Rules for Pressure Vessels

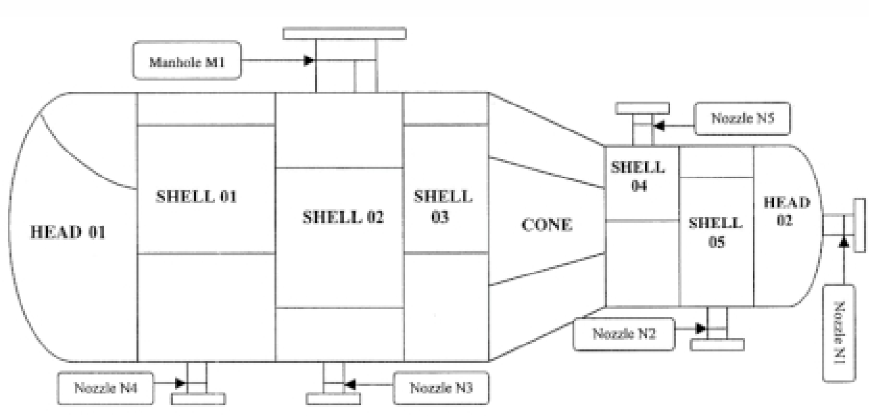


Figure 1: Typical Pressure Vessel

Methodology

The basic information for designing pressure vessels is formulated by the process engineering group and contains such criteria as that shown in the "Design Data Sheet (DDS)" (See Figure 2). Additional conditions that are to be considered during design, manufacture, and testing, along with technical/ commercial conditions of delivery, are furnished in a document called "Technical Specifications (TS)" which is part of the purchase order (PO).

Based on the DDS and the TS, design department of the fabricator performs the design calculations as per the applicable code, and a detailed fabrication drawing is prepared. This is, in turn, sent to the client for their approval. After the approval of the design and drawings by the client, the planning department of the fabricator generates material requisitions to the procurement department. The material requisition is just a translation of all the relevant data given in the drawing as well as in the TS in a form that can be understood by the vendor for that particular item.

The procurement department floats enquiry for materials to reputed vendors who are already registered with the fabricator. This department is primarily responsible for obtaining materials of required quality at the lowest price and within the stipulated time frame. The responsibility of the department ceases only when the material is received at stores and accepted by the quality assurance and control (QAC) department.

1 Customer/Client				
2 Customer Order No.				
3 Shop Order No.				
4 Design Drawing				
5 Specifications				
6 Vessel Name				
7 Equipment No.				
8 Design Code & Addenda				
9 Design Pressure	Internal		External	
10 Design Temperature				
11 Operating Pressure	Internal		External	
12 Operating Temperature				
13 Vessel Diameter				
14 Volume				
15 Contents & Specific Gravity				
16 Service				
17 Design Liquid Level				
18 Maximum Allowable Working Pressure				
19 Test Pressure	Shop		Field	
20 Heat Treatment				
21 Joint Efficiency				
22 Corrosion Allowance Shell				
Heads				
Nozzles				
Boot				
23 Materials Shell				
Heads				
Nozzles				
Flanges				
Bolting				
Supports				
24 Flange Ratings				
25 Weights	Fabricated		Operating	
	Empty		Test	
26 Notes / Remarks				

Figure 2: Design Data Sheet

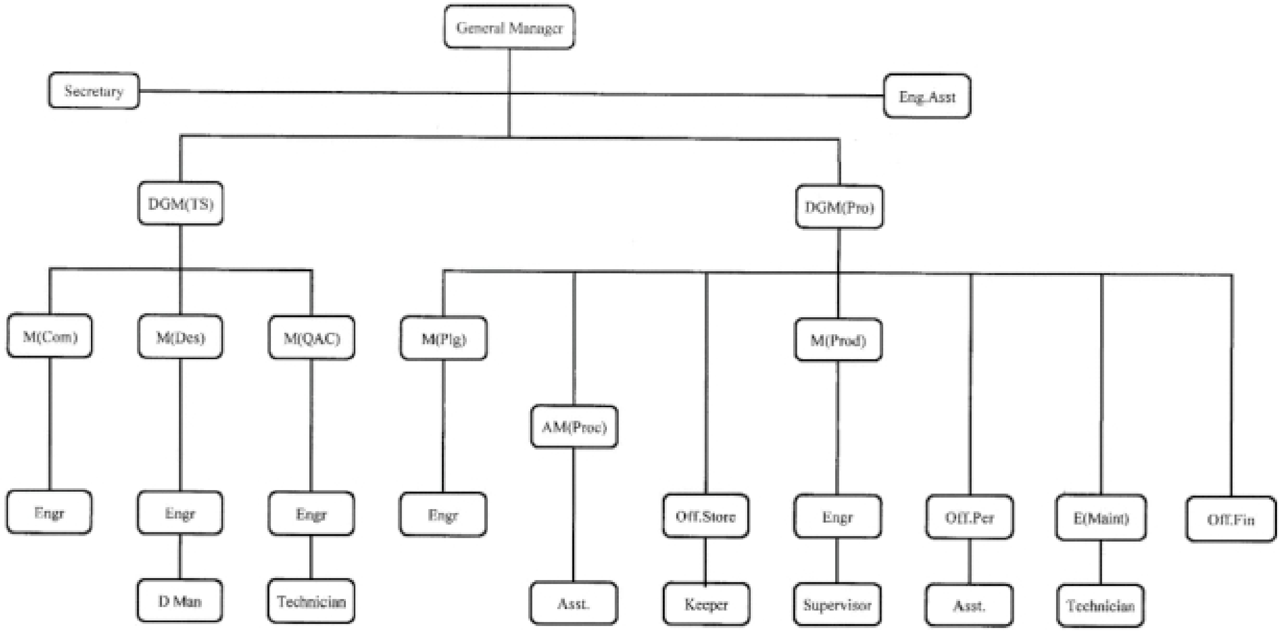
On receipt of the material, the planning department issues a work order (WO) to the production department with authorization to draw materials from stores along with certified-for-fabrication drawings and a detailed delivery schedule for the work.

The production department in turn works out its micro-level planning based on availability of manpower and machines to meet the deadlines committed to the client. The micro-level planning of the QAC department is carried out in such a way that it does not conflict with the overall production schedule nor the micro planning of the production. With the concerted efforts of all the departments, including service departments like stores, maintenance, personnel, finance etc., the targets for cost, time and quality can be met. If these targets are achieved, it paves way for the prosperity of the organization.

ORGANIZATION

In order to achieve the required level of quality in production, there should a well-defined organization in which all departments function as a team with a single corporate objective, rather than focus on the best performance of any individual department. The product quality shall in no case be lower than that that desired by the client in the specifications. At the same time it need not be of extremely high quality, in which case the product cost will also be very high. Repairs and reworks shall be avoided to the extent possible as they inevitably turn out to be very expensive in terms of both money and time.

The positions shown in the organization chart (Figure 3) can be broadly classified into three levels. The level consisting of the General Manager (GM) and the Deputy General Managers (DGMs) is called the top management; they make the policy and strategic decisions. The middle management level consists of Managers and Assistant Managers who make decisions on day-to-day affairs. They are also expected to brief the top management with an abridged version of all decisions and the results of the same for information management to be utilized for future policy decisions. Interdepartmental coordination is another major area of concern for middle managers, and they must communicate the goals set by top management to facilitate implementation by the junior managers of the company. The junior managers include engineers and supervisors. The engineers mostly carry out the theoretical and analytical part of the work, whereas the supervisors are expected to provide the labour management.



1) All levels below level III shall be workmen in respective desciplines.
2) As the nature of job is not continuous, posts below level III may be augmented on hire depending on need
3) Legends:-

DGM(TS)	Dy.General Manager(Technical Services)	M(QAC)	Manager(Quality Assurance & Control)	E(Maint)	Engineer(Maintenance)
DGM(Pro)	Dy.General Manager(Production)	M(Plg)	Manager(Planning)	Eng Asst	Engineering assistant to GM
M(Com)	Manager(Commercial)	M(Prod)	Manager(Production)	Off(Stores)	Officer(Stores)
M(Des)	Manager(Design & Drawing)	AM(Proc)	Asst. manager(Procurement)	Off(Per)	Officer(Personnel)
Off(Fin)	Officer(Finance)				

Figure 3: Organization Chart

Out of the positions described, the engineers generally man the engineering and procurement disciplines, whereas the officers and staff in the finance, personnel, and stores departments are from non-technical side.

DEPARTMENT FUNCTIONS AND RESPONSIBILITIES

Commercial Department

The commercial department is responsible for getting orders for the company by keeping in touch with the potential clients. A few of the salient responsibilities are as follows:

1. Keep the company in the approved vendor list of all prospective clients.
2. Obtain tender documents and make competitive offers, attending to technical discussions and clarifications along with the concerned engineers from the required departments, follow up on offers, and bag orders.
3. Enter into formal contracts with clients as needed to obtain orders.
4. Transfer PO and other documents pertaining to the contract to the concerned departments and explain to them the basis of estimation in a post-order meeting.
5. Promote the company in all appropriate potential avenues.

Design Department

The first step in the manufacture of pressure vessel is the design of the pressure vessel based on the DDS and the TS. Some of the major responsibilities of the department are:

1. Carry out the design as per applicable codes and client specifications; prepare fabrication drawings, submit design calculations and fabrication drawings for the approval of the client.
2. Issue the prepared drawings to all concerned departments to obtain feedback as to method and sequence of fabrication, and to incorporate such changes in the drawings.
3. Issue the certified-for-fabrication drawings to various departments to start the work.
4. Maintain reference standards like codes for the design and fabrication, and keep abreast with the latest design and fabrication trends.
5. Prepare as-built drawings.
6. Issue solutions to the material and fabrication problems, and suggest alternative materials and methods when needed.

Planning Department

This department is the backbone of the production even though they are not directly involved in the production function. A few major responsibilities of the department are:

1. Generate material requisitions to procurement department for raw materials other than that already available in the stores (Figure 4).
2. Issue work order and material authorization for shops to draw materials and to start with the actual execution of the job (Figures 5 and 6).
3. Schedule the shop loading based on machine and manpower availability.
4. Identify and monitor critical path activities, and keep management posted on schedules, targets and tasks.
5. Coordinate with all concerned departments.

Procurement Department

The basic function of this department is to procure materials as specified in the requisition of the planning department within the allocated budget and time. A few major functions of the department are:

1. Maintain an up-to-date approved vendor list on all raw materials, consumables and spares for the heavy machinery in the shop.
2. Obtain enquiries within the time frame specified by the planning department as per the DDS and TS, and at the lowest cost.
3. Place order with reliable parties and expedite them to ensure timely receipt at stores.
4. Collect the documents pertaining to supply and forward them to the concerned departments for further action.
5. Constantly upgrade and revise vendor list.

MATERIAL REQUISITION

Order No.		M R No.	
Purchaser		Date	
Description		Delivery date	

The following items may be procured for the above referred project as per the delivery schedule.

Sl.No.	Description	Applicable Specification	Quantity	Unit	Due Date

(Note: - As far as possible, one request may be used for one type of material only)

Figure 4: Format for Material Requisition

WORK ORDER

Order No.				Work Order No.	
Purchaser				Date	
Description				Quantity	
Drawing Numbers					

The production is hereby requested to manufacture ----number(s) of pressure vessels/ columns/ as per the above drawings with the salient features as below.

1	Vessel Identification Number(s)	
2	Design & Manufacturing Code	
3	Approximate Diameter & Length	
4	Design Pressure & Temperature	
5	Test Pressure	
6	Heat Treatment	
7	Joint Efficiency	
8	NDT requirements	
9	Material of Construction	
10	Inspection Agency	
11	Cleaning & Painting	
12	As Built Documents	

Figure 5: Work Order

Stores

All raw materials received and accepted will be under the custody of stores. They are expected to issue them to production based on authorization from the planning department. Listed here are a few of their salient functions:

1. Receive and store materials at the incoming stores area.
2. Offer materials to the QAC department for inspection through intimation of material receipt. (Figure 7)
3. Take all accepted materials to the stock and store them properly. The intimation of the materials shall be given to the planning department for further action.
4. Issue materials to users based on authorization from the planning department (for raw materials only)

MATERIAL AUTHORIZATION

Order No.		Authorization No.	
Purchaser		Date	
Description		Work Order Ref:	

The production is hereby authorized to draw the following materials received at stores as per the references indicated against each for the above referred work order. The scrap material against this project should be returned to stores on completion of the work with material reconciliation statement.

Sl.No.	Description	Quantity	Unit	PO & RR Details

Figure 6: Material Authorization

INTIMATION OF MATERIAL RECIEPT

Purchase Order No.		Date	
Vendor		Date of Receipt	

DETAILS OF ITEMS RECEIVED

Sl.No.	Tag No.	Description

Figure 7: Intimation of Material Receipt

Quality Assurance and Control Department

Even though QAC department is a service department to production, it has a higher responsibility to the client by the virtue of its function. Therefore, the department enjoys more autonomy than others and is manned by well-qualified personnel with a high degree of integrity. Listed here are some of their responsibilities:

1. Carry out the inspection of all incoming raw materials and the stores.
2. Prepare and obtain approval of all QAC procedures, including
    - Quality Assurance Plan (QAP)
    - Inspection and Test Plan (ITP)
    - Welding Procedure Specifications (WPS)
    - Procedure Qualification Records (PQR)
    - Welder Qualification Tests (WQT)
    - Non-Destructive Testing (NDT)
    - Post-Weld Heat Treatment (PWHT)
    - Hydrostatic Testing (HT)
3. Carry out stagewise inspection during manufacture and maintain records.
4. Carry out NDT and DT, as required, at various stages reporting on unacceptable defects, review rectification of defects through rigorous follow-ups with production, and maintain records.
5. Prepare NDT summary, weld summary, etc. along with weld maps and consolidation of same to check the completeness of NDT.
6. Witness various tests carried out during process of manufacture and prepare documents.
7. Coordinate with third party/ client for witnessing the hold points as laid out in the QAP and prepare documentation of the same.
8. Issue manufacturer's certificates for the vessels in the required format.
9. Prepare manufacturer's data report (MDR) and submit to the client, after approval by third party.
10. Supply information to the design department for the preparation of as-built drawings.
11. Perform quality auditing and reporting to top management on overall quality level of various departments directly in the manufacture of the vessel.

Production Department

The physical transformation of raw materials to a pressure vessel is the function of this department, even though a lot of effort goes into it prior to the start of manufacture. Listed here are some of the main functions:

1. Production of shells, dished ends, cones, subassemblies as per the engineering drawings, code practices, and the schedule of the planning department.
2. Feedback to planning on daily production status, problems, remedial measures, catch-up plans etc.
3. Offer materials/ products to QAC at various stages of fabrication for inspection.
4. Return balance materials to stores with proper identification and certification by the inspection department.
5. Perform the physical conduct of tests as per approved procedures and the instructions of QAC.
6. Keep current the calibration certificates for all measuring instruments.
7. Use proper procedures for manufacture of components based on the process to be used.
8. Perform the physical conduct of hydrostatic test and the post-hydrotest cleaning of the vessel.

9. Clean and paint the vessel as per the PO.

10. Pack the vessel for shipment as per the PO.

Maintenance Department

Improving the availability of machines required for production the main function of this department. A few other responsibilities are as follows:

1. Keep all machines in good order using proper preventive maintenance and scheduled shutdowns without affecting the production.
2. Prepare material requisition for spares and consumables for the smooth operation of the machines, including welding machines, grinders etc. apart from the heavy machinery.
3. Maintain all company vehicles for the transport of goods for production.

Personnel Department

All personnel matters are to be tackled by this department.

1. Recruitment, training, maintenance of personnel records, renewal of contracts, sanction of increments, fixation of pay etc.
2. Welfare measures for employees.
3. Office administration matters including housekeeping, postage, and other office facilities management.

Finance Department

Anything related to finance should be in finance department's scope of work.

1. Resources planning and allocation of funds for different jobs.
2. Accounting and its regularization and ratification with all statutory agencies.
3. Payroll for all employees.
4. Payment to all outside agencies on accounts of purchase of materials and services.

MANUFACTURE OF COMPONENTS

Pressure vessels consist of various components (as shown in Figure 1). The methods for the manufacture of the components must be in accordance with the requirements of the prevailing code. The methods described here are in accordance with the requirements of the ASME Section VIII, Division 1 code.

Components

1. Heads or dished ends
2. Shell (body of the vessel)
3. Cones or reducers
4. Attachments like nozzles, manholes, saddle supports, skirt supports, leg supports, trunnions, lifting lugs, platform and ladder supports, etc.

The manufacture of heads and cones is considered to be more difficult than that of shells due to difficulty in controlling the dimensions of these two items. For this reason, they should be made first (within the code tolerances), and shells are made later to suit these heads and cones.

Manufacturing Processes

The basic manufacturing process used in the fabrication of pressure vessel is forming. Forming is the process by which the size or shape of the part is changed by application of force that produces stresses in the part which are greater than the yield strength and less than the fracture strength. Depending on the temperature during fabrication, it is categorized as hot, warm, or cold forming. It is called hot working when the temperature is above the recrystallization temperature of the material, warm working if the temperature is sufficiently above room temperature but below recrystallization temperature, and cold working when the temperature is very much below the recrystallization temperature, for e.g., at room temperature. The manufacturing processes fall under the following headings:

- Pressing
- Spinning
- Bending

Pressing:

Pressing is the process usually adopted when the size of the part to be made is comparatively small. Domes and pipe caps are usually made using this process mostly at room temperature. This process is usually done in stages and it is a comparatively slow process. Shapes thus produced can have local deformation and hence the process calls for thorough inspection.

In cold pressing, due to effect of work hardening, the chances for surface cracks on the outer surface is very high and hence calls for liquid penetrant testing (LPT) during examination of surfaces. In hot pressing, utmost care shall be taken to see that the heating, the maintenance of heat during the process, and the subsequent cooling shall be strictly as per the procedure, as they have a great bearing on the grain structure of the material.

Spinning:

This process is used for making a variety of dished ends, namely torispherical, 2:1 ellipsoidal, toriconical and hemispherical. The specific advantages with this process are that the dished ends are made without the use of dies and it is the fastest process for the manufacture of dished ends.

Initially a hole of about 20mm diameter is made, preferably by drilling, at the center of the blank, and the crown portion is formed using local pressing. Later it is loaded onto the spinning machine; then while spinning the partially formed blank, using adjustable guide rollers, the final shape is given. As the blank is continuously spinning, the surface of the dished end is completely free from local deformations. Based on the thickness of the blank, machine capacity etc., the process is carried out either cold or hot.

Bending:

This process is conventionally called rolling, even though it is not rolling. Rolling is a process where a thickness reduction to a plate thickness takes place, whereas in bending not only a curvature is given to the plate and no thickness reduction is expected.

The usual practice of bending is by passing the plate through either a three- or a five-roll plate bending machine of adequate capacity to bend the plate to the required diameter. The most commonly used bending machine in fabrication industry is the three-roll plate bending machine (Figure 8). Prior to passing the full length of the plate through the rollers, both edges of the plate are pressed to the required radius. Once both the edges are pressed to the correct radius, the full length of the plate is passed through the rollers to impart curvature in steps. If the diameter is large and the thickness is comparatively less (say up to 10 mm), then the curvature can be given in one pass. However, if the thickness is high and the diameter is small, the full bending is to be carried out in stages.

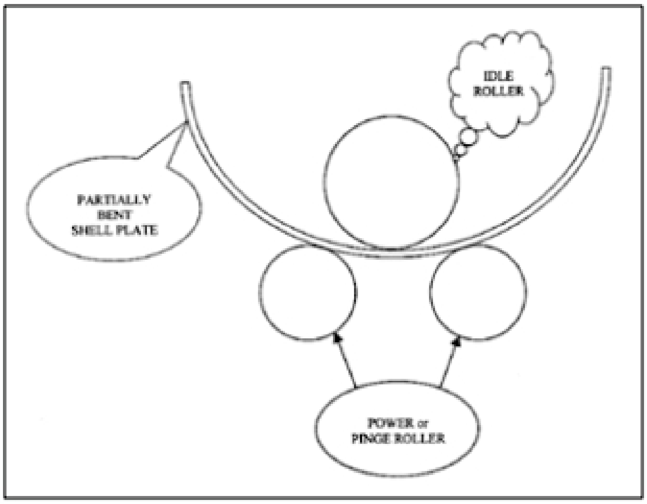


Figure 8: Schematic Diagram of Plate Bending

MANUFACTURE

For the manufacture of any component, the first step is to identify the material to be used for the job. For this the material test certificate is essential. As all raw materials have undergone incoming inspection at stores, it is presumed that detailed scrutiny was done there. However, verification as to the material specification and heat numbers stamped on the plate has to be carried out with respect to that given in the certificate and the specification in the drawing.

If a few pressure parts are to be made from a plate, say dished head, cone etc., then the identification on the plate has to be transferred to all the parts. Sufficiently large scrap plate is also identified in the same way. Figure 9 shows the actual work with all the transferred markings.

The material identification shall be carried out for each and every pressure part of the vessel and as far as possible, the material identification stamping shall be on the outside of the vessel so that they can be verified at any point in time during the manufacturing process. The stamping is carried out using low stress stamps; hard punching is not allowed. When stamping is done on dished heads, it is on the crown portion where the deformation is minimal.

Flat Heads:

Flat heads are usually made by forging; so it is a bought out item and is subjected to raw material inspection at the receiving department. The main dimensions that are to be checked are the diameter and thickness of the flat head. The diameter is measured at least at 0, 45, 90, and 135o (in four directions) - see Figure 9. Being a flat surface, obviously the flatness also has to be checked. Apart from these, there is nothing else to be checked for a flat head.

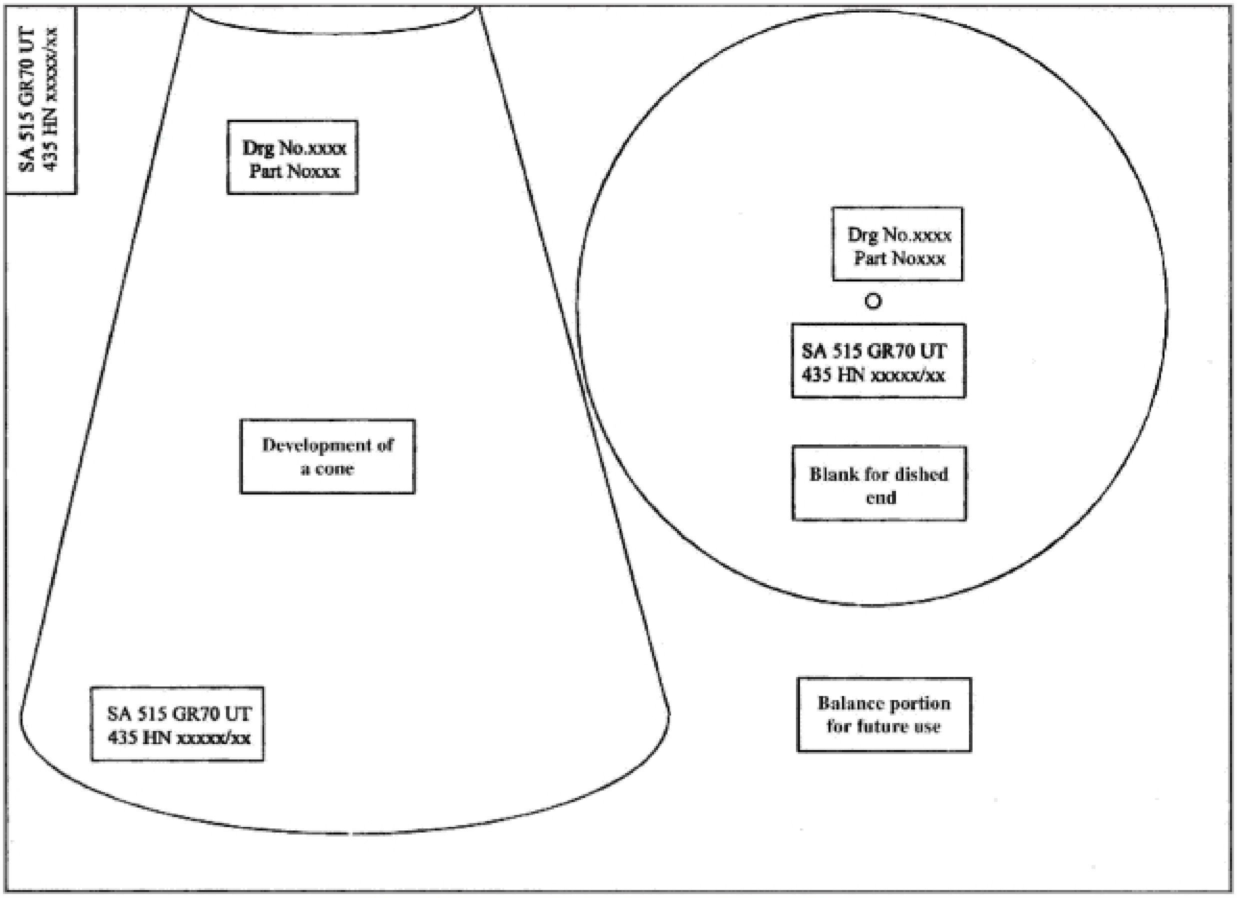


Figure 9: Plate Marking and Transfer of Identification

Dished Heads:

Dished heads are made by cold or hot pressing and in combination process of pressing and spinning. Heads of comparatively smaller size and lower thickness are made either by cold pressing or hot pressing, whereas larger sized heads are made by combination process of both pressing and subsequent spinning. It has been mentioned earlier that for spinning the dished heads, a hole of approximately 20 to 30 mm in diameter has to be provided at the center of the blank for holding during spinning. In case any nozzles are to be attached at the center of the head, the opening is enlarged to fit the nozzle. If not, the hole has to be plugged, either by welding alone, or by welding in a plug whose thickness will match the thickness of the head at that place.

The dimensions to be checked for dished heads are as follows (Figure 11):

1. Actual inside diameter at a minimum of four locations
2. Outside circumference at straight flange (SF) and thickness at SF from at least 12 locations
3. Depth of dish (inside) excluding SF, and SF
4. Thickness reading at 100-mm spacing along four lines radiating from the center of the head to SF at 0, 90, 180 and 270o marked on the outside surface at SF using an ultrasonic thickness gage (UTG)

Shell:

If the length of the plate is sufficient to accommodate the full circumference of the shell, this is the preferred condition because the shell will have only one longitudinal seam. The plate is first cut to required length and breadth, and bevel is prepared on all four sides. The square cutting and bevel preparation is carried out by oxyacetylene flame for carbon steel plates, and by plasma-arc process for stainless and high alloy steels. The cut edges are then ground back to sound metal at least by 1 to 1.5 mm so that all adversely affected material in the cut zone is removed. This will help in preventing the oxidized metal from going into the weld pool, thereby making the weld incompatible to the base metal.

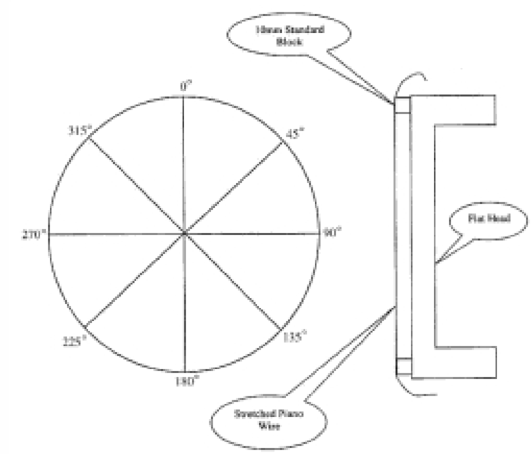


Figure 10: Dimensional Check of Flat Heads

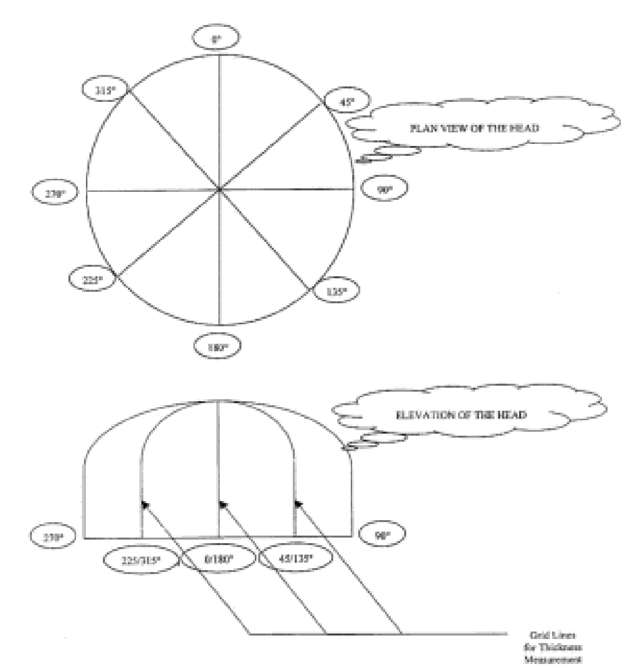


Figure 11: Dimensional Check of Dished Heads

If the length of the plate is not sufficient for making the shell, two or more plates are joined together to obtain the required shell length. The plate is bent only after completing the weld from both sides. The reinforcement is ground off to the base metal level to facilitate the smooth bending of the plate. In case seams are to be radiographed, it is to be done after bending.

The following dimensions for shell are checked (Figure 12):

1. Outside circumference at both ends as well as at the center of the shell
2. Inside or outside diameter at four angles on either side of the shell
3. Straightness of the shell through center lines at 0, 90, 180 and 270o
4. Length of the shell at four center lines

Cones:

Cones are produced by two methods. When the thickness is comparatively small and the diameter is comparatively large, it can be made in plate bending machine by independently adjusting the pressure rollers at both ends of the bending machine. This work needs expert operators compared to the shell bending. When the thickness of the cone is larger and the diameter is smaller, cones are made by pressing. The pressing is carried out using matching male and female dies either in full length or in pieces depending on the machine capacity.

The following dimensions are measured (Figure 13):

1. Outside circumference at both the ends
2. Inside or outside diameter at both ends
3. Slant height of the cone at four diametrically opposite points
4. Straightness of the cone in cases of larger slant height or when circumferential seams are unavoidable
5. Thickness at random points
6. Profile at both ends
7. Concentricity

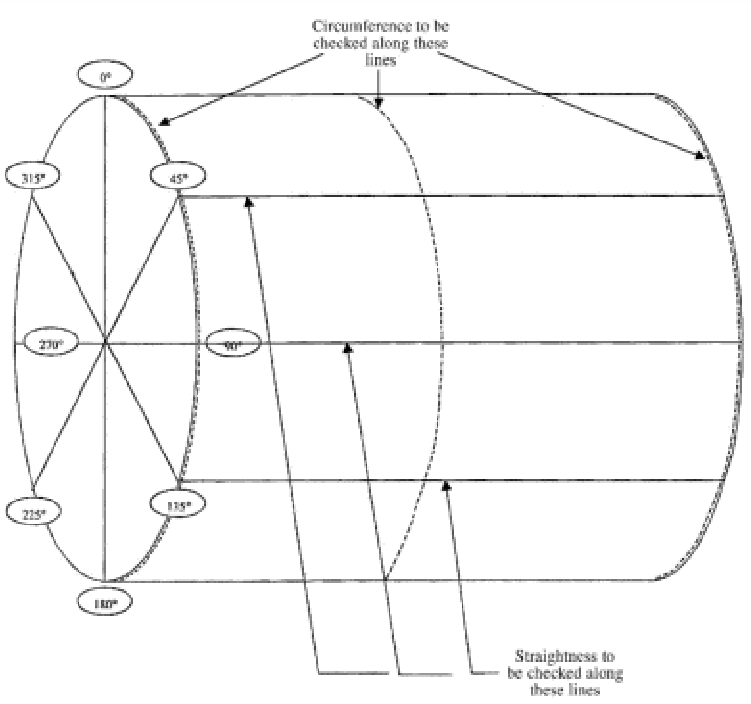


Figure 12: Dimensional Check of Shells

DESTRUCTIVE AND NONDESTRUCTUVE TESTING REQIREMENTS

For carrying out DT/NDT, the relevant sections of ASME Sections VIII, Div. 1 and Section V are to be followed as needed and must be closely monitored by the QAC department.

Destructive Testing:

The usual destructive testing envisaged by the Code is impact testing. A minimum of three tests are be performed and the average value is considered for acceptance. These tests are to be carried out on specimens taken from weld, heat affected zone (HAZ), and the base metal. The temperature at which test is carried out is given in the drawing, and a suitable bath is used to generate the required temperature. Up to -50oC, dry ice is very effective. As there is no positive record of these tests, it is done in the presence of the engineer or the third party inspector, as needed.

As far as possible, the test is carried out using standard specimens of 10 mm x 10 mm cross section. Smaller specimens are used when the thickness of the welded part is below 10 mm. The acceptance of these test results are in paragraph UG-84.

Nondestructive Testing:

The most commonly deployed method of NDT in manufacture of pressure vessel is radiographic testing (RT). There are only three categories of NDT requirement - full, spot and nil. This decision basically depends on the thickness, thickness and joint efficiency used in the design.

1. For full RT, all butt welds in the shell and the head have to be fully radiographed
2. Circumferential seam welds on nozzles below 10 in. need not be radiographed if the thickness of the nozzle is less than 1-1/8 in.
3. For spot RT, one spot on each vessel is tested for each 50-ft increment of the weld or fraction thereof. For nozzles the very same condition for full RT applies.
4. The acceptance criteria for all RT shall be as per UW-51 and UW-52 for linear defects and Appendix 4 for rounded indications.

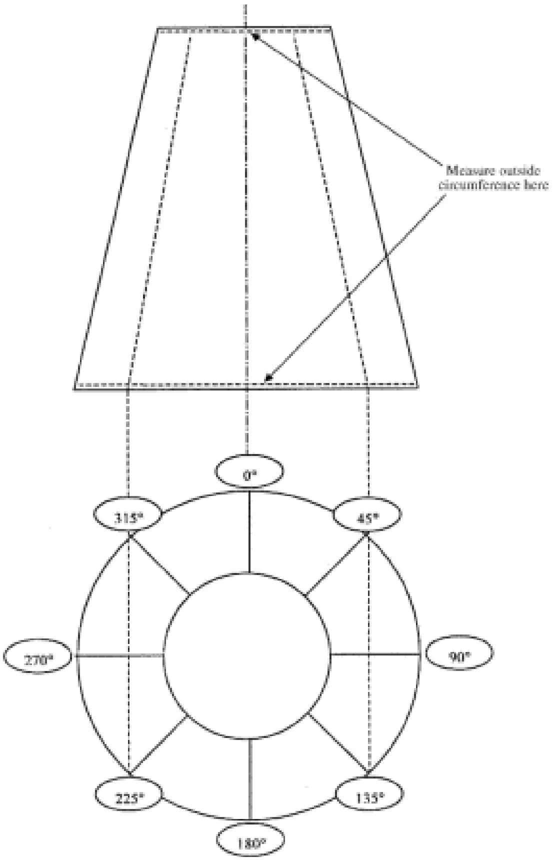


Figure 13: Dimensional Check of Cones

From the applicable specification UW-11, ultrasonic examination carried out in accordance with UW-53 may be substituted for radiography for the final closure seam of the pressure vessel if the construction of the vessel does not permit interpretable radiographs. The technique adopted and the acceptance criteria should be in accordance with Appendix 12 of ASME Section VIII, Div. 1

For magnetic particle testing (MPT) and liquid penetrant testing (LPT), the applicable sections are UG-93 and UHT-57 respectively. Appendices 6 and 8 further provide the basic requirements on methodology and the acceptance criteria.

RECORDS:

For all DT, reports must be generated and countersigned by all the parties who witness the test. If required by the client, the DT will consist of all weld tensile, transverse tensile, and bend tests; and charpy impact hardness tests. Mostly if there is a requirement, it will be only for impact testing at a low temperature.

Similarly, every RT taken under a particular technique is to be recorded in a report form along with the findings. These will be reviewed by a qualified and trained person according to the acceptance criteria, which again will be recorded in the report and will form a part of the final QAC documentation pertaining to the vessel.

Sources:

1. Practical Guide to Pressure Vessel Manufacturing, by Sunil Pullarcot

END OF THE ARTICLE

About CoDesign Engineering:

CoDesign Engineering specializes in the core business of providing training and consultancy for design and fabrication of ASME code pressure vessels, and the ecosystem that includes piping, welding, valves, geometric dimensioning and tolerancing, process improvement, and engineering management. Some of the training courses (lasting from two days to five days) that we provide include:

- Design and Fabrication of ASME Section VIII, Div. 1 Pressure Vessels
- Shell & Tube Heat Exchangers - Thermal and Mechanical Design
- Process and Power Piping
- Renewable Energy - Solar & Biogas
- Design and Fabrication of ASME Section VIII, Div. 2 Pressure Vessels
- ASME Section IX - Welding Technology
- Engineering Materials

We also provide several one-day workshops:

- Know Your Power Piping
- Know Your ASME Section VIII Pressure Vessel Code
- A to Z of Pressure Vessels
- Know Your Process Piping
- Know Your Shell & Tube Heat Exchangers
- Transitioning to ASME Section VIII, Div. 2

Our trainings can be offered at most cities worldwide.

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RAMESH TIWARI

Ramesh Tiwari holds a Master's degree in Mechanical Engineering from Clemson University in South Carolina, and is a registered Professional Engineer from the state of Maryland in the United States. He has over 22 years of experience designing pressure vessels, heat exchangers and tanks. Ramesh is a member of ASME Section VIII Subgroup on Heat Transfer Equipment, and member of ASME B31.1 IWG for Power Piping. He is also an approved pressure vessel instructor at National Thermal Power Corporation (NTPC), a premier thermal power generating company in India; and TUV India of TUV Nord Group, one of the world's largest Inspection, Certification and Testing Organizations.

Disclaimer :

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