(a) The thickness of a segment of a miter shall be determined in accordance with NC-3641. The required thickness thus determined does not allow for the discontinuity stresses which exist at the junction between segments. The discontinuity stresses are reduced for a given miter as the number of segments is increased. These discontinuity stresses may be neglected for miters in noncyclic services with incompressible fluids at pressures of 100 psi (700 kPa) and under, and for gaseous vents to atmosphere. Miters to be used in other services or at higher pressures shall meet the requirements of NC-3649.

(b) The number of full pressure or thermal cycles shall not exceed 7,000 during the expected lifetime of the piping system.

(c) The angle θ in Table NC-3673.2(b)-1 shall not be more than 22°/2 deg.

(d) The center line distance between adjacent miters shall be in accordance with Table NC-3673.2(b)-1.

(e) Full penetration welds shall be used in joining miter segments.

NC-3645 Attachments

(a) External and internal attachments to piping shall be designed so as not to cause flattening of the pipe, excessive localized bending stresses, or harmful thermal gradients in the pipe wall. It is important that such attachments be designed to minimize stress concentrations in applications where the number of stress cycles, due either to pressure or thermal effect, is relatively large for the expected life of the equipment.

(b) Attachments shall meet the requirements of NC-3135.

(c) The effect of rectangular and circular cross section welded attachments on straight pipes may be evaluated using the procedures in Nonmandatory Appendix Y.

NC-3646 Closures

(a) Closures in piping systems shall be provided in all branch connections. Flanged fittings, such as blind flanges or threaded or welded plugs or caps, either manufactured in accordance with standards listed in Table NCA-7100-1 and used within the specified pressure-temperature ratings, or made in accordance with (b) below.

(b) Closures not manufactured in accordance with the standards listed in Table NCA-7100-1 may be made in accordance with the rules contained in NC-3300 of this Subsection using the equation

\[ t_m = t + A \]

where

- \( t_m \) = the minimum required thickness, in. (mm)
- \( t \) = pressure design thickness calculated for the given closure shape and direction of loading using appropriate equations and procedures in NC-3000, in. (mm)
- \( A \) = sum of mechanical allowances (NC-3613), in. (mm)

(c) Connections to closures may be made by welding, extruding, or threading. Connections to the closure shall be in accordance with the limitations provided in NC-3643 for branch connections. If the size of the opening is greater than one-half the inside diameter of the closure, the opening shall be designed as a reducer in accordance with NC-3648.

(d) Other openings in closures shall be reinforced in accordance with the requirements of reinforcement for a branch connection. The total cross-sectional area required for reinforcement in any plane passing through the center of the opening and normal to the surface of the closure shall not be less than the quantity of \( d_s t \), where

\[ d_s = \text{diameter of the finished opening, in. (mm)} \]

\[ t = \text{pressure design thickness for the closure, in. (mm)} \]

NC-3647 Pressure Design of Flanged Joints and Blanks

NC-3647.1 Flanged Joints.

(a) Flanged joints manufactured in accordance with the standards listed in Table NCA-7100-1, as limited by NC-3612.1, shall be considered as meeting the requirements of NC-3640.

(b) Flanged joints not included in Table NCA-7100-1 shall be designed in accordance with XI-3000.

NC-3647.2 Permanent Blanks. The minimum required thickness of permanent blanks (Figure NC-3647.2-1) shall be calculated from the following equations:

\[ t_m = t + A \]

where

- \( t_m \) = the minimum required thickness, in. (mm)
- \( t \) = pressure design thickness calculated from the equation below, in. (mm)
- \( A \) = the sum of the mechanical allowances, in. (mm) (NC-3613)

\[ t = d_k \left( \frac{3P}{16S} \right)^{1/2} \]

\[ t_m = \text{the minimum required thickness, in. (mm)} \]

where

- \( d_k \) = the inside diameter of the gasket for raised or flat face flanges or the pitch diameter of the gasket for retained gasketed flanges, in. (mm)
- \( P \) = Design Pressure, psi (MPa)
- \( S \) = the allowable stress in accordance with Section II, Part D, Subpart 1, Tables 1A and 1B, ksi (MPa)

NC-3647.3 Temporary Blanks. Blanks to be used for test purposes only shall have a minimum thickness not less than the pressure design thickness \( t \) calculated as in NC-3647.2 above, except that \( P \) shall not be less than the test pressure and the allowable stress \( S \) may be taken as 95% of the specified minimum yield strength of the blank material (Section II, Part D, Subpart 1, Table Y-1).
\[ t = \text{pressure design thickness, calculated for the given closure shape and direction of loading using appropriate equations and procedures in ND-3000, in. (mm)} \]
\[ t_m = \text{minimum required thickness, in. (mm)} \]

(c) Connections to closures may be made by welding, extruding, or threading. Connections to the closure shall be in accordance with the limitations provided in ND-3643 for branch connections. If the size of the opening is greater than one-half the inside diameter of the closure, the opening shall be designed as a reducer in accordance with ND-3648.

(d) Other openings in closures shall be reinforced in accordance with the requirements of reinforcement for a branch connection. The total cross-sectional area required for reinforcement in any plane passing through the center of the opening and normal to the surface of the closure shall not be less than the quantity of \( d_s t \), where

\[ d_s = \text{diameter of the finished opening, in. (mm)} \]
\[ t = \text{pressure design thickness for the closure, in. (mm)} \]

**ND-3647 Pressure Design of Flanged Joints and Blanks**

**ND-3647.1 Flanged Joints.**

(a) Flanged joints manufactured in accordance with the standards listed in Table NCA-7100-1, as limited by ND-3612.1, shall be considered as meeting the requirements of ND-3640.

(b) Flanged joints not included in Table NCA-7100-1 shall be designed in accordance with XI-3000.

**ND-3647.2 Permanent Blanks.** The minimum required thickness of permanent blanks (Figure ND-3647.2-1) shall be calculated from the following equations:

\[ t_m = t + A \]

where

\[ A = \text{sum of mechanical allowances (ND-2613), in. (mm)} \]
\[ t = \text{pressure design thickness calculated from the equation above, in. (mm)} \]
\[ t_m = \text{minimum required thickness, in. (mm)} \]

\[ t = d_6 \left( \frac{3p}{16S} \right)^{1/2} \]

where

\[ d_6 = \text{the inside diameter of the gasket for raised or flat face flanges or the pitch diameter of the gasket for retained gasketed flanges, in. (mm)} \]
\[ P = \text{Design Pressure, psi (MPa)} \]
\[ S = \text{the allowable stress in accordance with Tables 1A, 1B, and 3, Section II, Part D, Subpart 1, psi (MPa)} \]

**ND-3647.3 Temporary Blanks.** Blanks to be used for test purposes only shall have a minimum thickness not less than the pressure design thickness \( t \) calculated as in ND-3647.2, except that \( P \) shall not be less than the test pressure and the allowable stress \( S \) may be taken as 95% of the specified minimum yield strength of the blank material (Section II, Part D, Subpart 1, Table Y-1).

**ND-3647.4 Flanges.** Flanges shall be integral or be attached to pipe by welding, brazing, threading, or other means within the applicable standards specified in Table NCA-7100-1.

**ND-3647.5 Gaskets.**

(a) Gaskets shall be made of materials that are not injuriously affected by the fluid or by temperatures within the Design Temperature range.

(b) Only metallic or asbestos metallic gaskets may be used on flat or raised face flanges if the expected normal service pressure exceeds 720 psi (5 MPa) or the temperature exceeds 750°F (400°C). However, compressed sheet asbestos confined gaskets are not limited as to pressures, provided the gasket material is suitable for the temperatures.

(c) The use of metal or metal asbestos gaskets is not limited as to pressure, provided the gasket materials are suitable for the fluid Design Temperature.

**ND-3647.6 Bolting.**

(a) Bolts, stud bolts, nuts, and washers shall comply with applicable standards and specifications listed in Table NCA-7100-1. Unless otherwise specified, bolting shall be in accordance with the latest edition of ASME B16.5. Bolts and stud bolts shall extend completely through the nuts.

(b) Studs shall be threaded full length or shall be machined down to the root diameter of the thread in the unthreaded portion, provided that the threaded portions are not less than 8 inches in length. Studs greater than 8 inches in length may have an unthreaded portion that has a root diameter of the thread, provided the following requirements are met:

1. The threaded portions shall be at least \( 1\frac{1}{2} \) inches in length;
2. The stud shall be machined down to the root diameter of the thread for a minimum distance of 0.5 inches adjacent to the threaded portion; and
3. A suitable transition shall be provided between the root diameter and unthreaded portions.

(c) Carbon steel bolts shall be square or heavy hexagon head bolts and shall have heavy semifinished hexagon nuts.

(d) Alloy steel stud bolts shall have heavy hexagon nuts. Headed alloy bolts are not recommended.

(e) It is recommended that all alloy bolts or stud bolts and accompanying nuts be threaded in accordance with ASME B1.1 Class 2A external threads and Class 2B internal threads.
2013 SECTION III APPENDICES

O-1300 STRESS EVALUATION OPEN SYSTEM

Evaluation of stresses due to the design mechanical loads may be made by using the rules for Class 1 piping, O-1310 and for Class 2 or Class 3 piping, O-1320.

O-1310 CLASS 1 PIPING

(a) Whenever any of the equations of NB-3650 are used in the analysis of Class 1 piping systems, the value of $M_r$ shall include the reaction force moment. The contribution from the reaction force $F$ to the branch moment $M_B$, as defined in Note (5) of Table NB-3682.2-1, shall be no less than the product $F \times \text{nominal discharge pipe size} \times \text{DLF}$.

(b) Note that the use of the equations of NB-3650 for branch connections requires a nozzle spacing as defined by NB-3666.1(c) or NB-3683.8 (a) (2).

(c) When eq. (9) of NB-3650 is used in the analysis, the value of $M_r$ shall be defined as:

$$M_r = \text{resultant moment due to a combination of primary loads. Loads to be considered include: weight; earthquake, considering only one-half the range of the earthquake and excluding the effects of anchor displacement due to earthquake; thrusts from relief and safety valve loads from pressure and flow transients; and other sustained mechanical loads.}$$

(d) The combination of loads shall be specified in the Design Specification. In the combination of loads, all directional moment components in the same direction shall be combined before determining the resultant moment; i.e., resultant moments of loads shall not be combined.

(e) When eq. (10) of NB-3650 is used in the analysis, the value of $M_r$ shall be defined as:

$$M_r = \text{resultant range of moment due to a combination of primary plus secondary loads. Loads to be considered include: thermal expansion; anchor movement from any cause; earthquake effects; thrusts from relief and safety valve loads from pressure and flow transients; and other mechanical loads.}$$

(f) The combination of loads shall be specified in the Design Specification. The earthquake loading shall be considered in conjunction with the operating conditions. Weight effects need not be considered in the range loading because they are noncyclic in character. In the combination of loads, all directional moment components in the same direction shall be combined before determining the resultant moment; i.e., resultant moments of loads shall not be combined. If a combination includes earthquake effects, $M_r$ shall be the greater of the resultant range of moment due to the combination of all loads considering one-half the range of the earthquake or the resultant range of moment due to the full range of the earthquake.

O-1320 CLASS 2 OR CLASS 3 PIPING

(a) For Class 2 or Class 3 piping, eq. (9) of NB-3652 or NB-3652.2 is to be used with $M_B$ to include the reaction force moment. The contribution from the reaction force $F$ to the branch moment, as defined in NB-3652.2 or NB-3652.2.2, shall be no less than the product $F \times \text{nominal discharge pipe size} \times \text{DLF}$.

(b) Note that the use of eq. (9) of NB-3652 or NB-3652.2 is for branch connections requires a nozzle spacing, as defined by NB-3643.3(c)(6) or ND-3643.3(c)(6).

O-1400 CLOSED DISCHARGE SYSTEMS — OPEN DISCHARGE SYSTEMS WITH LONG DISCHARGE PIPES — SYSTEMS WITH SLUG FLOW

(a) For closed discharge systems, open discharge systems with long discharge pipes, and systems with slug flow, the state of the art does not lend itself to a well defined method of load computation. For these systems, the dynamic interaction forces of the total system including the attached discharge piping must be considered.

(b) When a safety valve discharge is connected to a relatively long run of pipe and is suddenly opened, there is a period of transient flow until the steady-state discharge condition is reached. During this transient period, the pressure and flow will not be uniform. When the safety valve is initially opened, the discharge pipe may be filled with air. If the safety valve is on a steam system, the steam discharge from the valve must purge the air from the pipe before steady state steam flow is established and, as the pressure builds up at the valve outlet flange and waves start to travel down the discharge pipe, the pressure wave initially emanating from the valve will steepen as it propagates, and it may steepen into a shock wave before it reaches the exit.

(c) Relief valves discharging into an enclosed piping system create momentary unbalanced forces which act on the piping system during the first few milliseconds following relief valve lift. The pressure waves traveling through the piping system following the rapid opening of the safety valve will cause bending moments in the safety valve discharge piping and throughout the remainder of the piping system. In such a case, the designer must compute the magnitude of the loads and perform appropriate evaluation of their effects.

(d) Particular attention should be given to the large forcing functions acting on the pipe if it contains water seals, two phase flow, or if there is a water column in the discharge piping.

(e) The reaction force effects are dynamic in nature. A time history dynamic solution, incorporating a multi-degree-of-freedom model solved for the transient hydraulic forces is considered to be a preferred method of analysis.
O-1500  DESIGN CONSIDERATIONS

Reference should be made to NB/NC/ND-7000. It is recommended that the following be included as part of the total design consideration.

(a) Where not required by the Code, it is recommended that the header penetrations for relief valves be in accordance with the nozzle spacing recommendation of NB-3686.1(c), NB-3688.3 (a), (b).

(b) No more than one penetration should be made around the circumference of the run pipe (i.e., no two penetrations in the same transverse plane), the spacing to be in accordance with the preceding (a).

(c) The stress analysis of the pipe could require additional thickness for membrane protection above that required by the thickness equation for pressure load only.

(d) Detail design should preclude sharp notches that may be generated by the use of saddles, gussets, ribs, etc.

(e) Contoured outlets are often advantageous.

(f) The direction of discharge of several pressure relief valves on the same run pipe should be such as to tend to balance one another for all modes of operation specified in the piping design specification.

(g) Supports may require a detailed analysis to determine their role in restraint as well as support. Considerations should be given to the possibility that, under load, snubbing devices may permit significant deflections.

(h) The reaction force moment arm on the outlet piping should be minimized in accordance with the manufacturer’s recommendation.

(i) The relief valve outlet piping stack clearance should be checked for interference from thermal expansion, earthquake displacements, etc. The vent stack and valve discharge piping system should be arranged such that pull out of the valve discharge pipe does not occur.

(j) Thermal expansion effects are to be considered as they presently are defined in the Code.

(k) The force due to venting should be included in the evaluation of the stack forces. The effects of back pressure in the discharge stack can be significant.

(l) The station should be arranged such that the discharge piping is void of collected water. The discharge piping from each valve or device should be at least of the same size as the valve outlet.

(m) Drains shall be provided so that condensed leakage, rain, or other water sources will not collect on the discharge side of the valve and adversely affect the reaction force. Safety valves are generally provided with drain plugs that can be used for a drain connection. Discharge piping shall be sloped and provided with adequate drains if low points are unavoidable in the layout.

(n) Where water seals are used ahead of the safety valve, the total water volume in the seals should be minimized. To minimize forces due to slug flow or water seal excursion, the number of changes of direction and the lengths of straight runs of piping should be limited.

(o) Often safety valves are full lift, pop-type valves and are essentially full flow devices with no capability for flow modulation. In actual pressure transients, the steam flow required to prevent overpressure is a varying quantity, from zero to the full rated capacity of the safety valves. As a result, the valves may be required to open and close a number of times during the transient. Since each opening and closing produces a reaction force, consideration should be given to the effects of multiple valve operations on the piping system, including supports.