b) The completed pressure vessel shall be pressure tested in the shop or in the field in accordance with the original code of construction. When required by the Jurisdiction, owner or user, the Inspector shall witness the pressure test of the completed installation, including piping to the pressure gage, pressure relief device, and, if present, level control devices.

## 4.7 REQUIREMENTS FOR HOT WATER STORAGE TANKS

### 4.7.1 SUPPORTS

Each hot water storage tank shall be supported in accordance with NBIC Part 1, 1.6.1.

### 4.7.2 CLEARANCE AND ACCEPTABILITY

a) The required nameplate (marking or stamping) should be exposed and accessible.

b) The openings when required should be accessible to allow for entry for inspection and maintenance.

c) Each hot water storage tank shall meet the requirements of NBIC Part 1, 4.3.2.



### 4.7.3 TEMPERATURE AND PRESSURE RELIEF DEVICES

a) Each hot water storage tank shall be equipped with an ASME/NB certified temperature and pressure relief device set at a pressure not to exceed the maximum allowable working pressure and 210°F (99°C).

b) The temperature and pressure relief device shall meet the requirements of NBIC Part 1, 4.5.

### 4.7.4 THERMOMETERS

a) Each hot water storage tank shall be equipped with a thermometer.

b) Each hot water storage tank shall have a thermometer so located that it shall be easily readable at or near the outlet. The thermometer shall be so located that it shall at all times indicate the temperature of the water in the storage tank.

### 4.7.5 SHUT OFF VALVES

a) Each hot water storage tank shall be equipped with stop valves in the water inlet piping and the outlet piping in order for the hot water storage tank to be removed from service without having to drain the complete system.

b) Each hot water storage tank shall be equipped with a bottom drain valve to provide for flushing and draining of the vessel.

### 4.7.6 TESTING AND ACCEPTANCE

Testing and acceptance shall be in accordance with NBIC Part 1, 4.6

# PART 1, SECTION 5
# INSTALLATION — PIPING

## 5.1 SCOPE

This section provides requirements and guidelines for the installation of piping.

## 5.2 GENERAL REQUIREMENTS

For piping, the basic considerations are: the design temperature, the pressure retained by the pipe, the fluid in the pipe, the load resulting from the thermal expansion or contraction, and impact or shock loads imparted (such as water hammer, external loads, wind loads and vibration from equipment).

### 5.2.1 ADDITIONS TO EXISTING PIPING

Additions to existing piping systems shall conform to this section. That portion of the existing piping system that is not part of the addition need not comply with this section provided the addition does not result in a change in piping system operation or function that would exceed the design conditions of the existing piping system or result in unsafe conditions.

### 5.2.2 PROXIMITY TO OTHER EQUIPMENT AND STRUCTURES

The arrangement of the piping and its appurtenances shall take into consideration the location of other structures and equipment adjacent to the piping, which may result in freezing, interference and/or damage as a result of expansion, contraction, vibration, or other movements.

### 5.2.3 FLANGES AND OTHER NON-WELDED JOINTS

The layout of the piping shall take into consideration the need for required access to maintain and inspect piping joints.

### 5.2.4 VALVES

a) Valves are used in piping systems to stop and start the flow of fluids, to regulate the flow, to prevent the back-flow, and to relieve excessive pressure buildup in piping.

b) Consideration should be given to the appropriate location and orientation of valves necessary for safe operation and isolation of the piping. To reduce the effects of downstream disturbances, if possible, install the valve at least the distance of eight pipe diameters downstream from the closest elbow or pump.

c) Verify the pressure and temperature information on the valve conforms to the piping design requirements.

d) Clean the piping of all debris which could cause damage to the valve seat, disc, or bearings. Failure to lift the valve properly may cause damage. Lift the valve assembly with slings, chains, or cables fastened around the valve body. Lifting devices may be fastened to rods running through bolt holes in the flanges. Do not fasten lifting devices to the actuator or the disc and never put any lifting devices through the seat opening.

### 5.2.5 MATERIALS

All materials for piping and its appurtenances shall comply with the requirements of the code of construction.

### 5.2.6 HANGERS AND SUPPORTS

Support of piping shall consider loads (including wind and seismic loads) imposed on equipment or existing piping to which it is attached. Non-piping attachments such as ladders and walkways, equipment supports, temporary supports, structural supports, etc., shall not be connected to the piping unless such loads have been considered in the design of the piping and its supports. Design of hangers and supports for piping shall consider loads imposed by hydrostatic pressure testing. The installer shall remove pins from non-rigid hangers and seal plugs from hydraulic snubbers and temporary supports used for installation prior to placing the piping in service.

### 5.2.7 PROTECTION AND CLEANING

The installer shall exercise care during installation to prevent loose weld material, welding rods, small tools, and miscellaneous scrap metal from getting into the piping. The installer shall inspect and, where necessary, clean the interior of the piping and its appurtenances where possible, prior to making the final closures for the presence of foreign debris.



### 5.2.8 WELDING AND BRAZING

The installer should consider the impact of performing any preheating, welding, brazing, or postweld heat treatment on valves, instrumentation, or other heat sensitive equipment and, where appropriate, review the equipment manufacturer's recommended installation procedures prior to performing the work.

### 5.2.9 BOLTING

All mechanical joints and connections shall conform to manufacturers' installation instructions and recognized standards acceptable to the Jurisdiction having authority.

## 5.3 PRESSURE RELIEF DEVICES

When required by the original code of construction, piping shall be protected by pressure relief devices in accordance with the following requirements.

### 5.3.1 DEVICE REQUIREMENTS

a) Pressure relief devices shall be manufactured in accordance with a national or international standard and be certified for capacity or flow resistance by the National Board.

   1) In certain cases piping codes of construction permit the use of regulators, which may include integral pressure relief valves to limit the pressure in a piping system. In this case, capacity certification of the pressure relief valve is not required.

   2) Some piping codes of construction permit the use of pressure relief devices without capacity certification. In this case, capacity certification of the pressure relief device by the National Board is not required.

b) Dead weight or weighted lever pressure relief devices shall not be used.

c) Pressure relief devices shall be selected (i.e., material, pressure, etc.) and installed such that their proper functioning will not be hindered by the nature of the piping system's contents.

### 5.3.2 NUMBER OF DEVICES

At least one pressure relief device shall be provided for protection of a piping system. A pressure relief device installed on a pressure vessel or other component connected to the piping system may be used to meet this requirement. Portions of piping systems with different maximum allowable working pressures shall have a pressure relief device to protect each portion separately.

### 5.3.3 LOCATION

Pressure relief devices, except those covered by Sections 2 and 3 of this part, may be installed at any location in the system provided the pressure in any portion of the system cannot exceed the maximum over-pressure permitted by the original code of construction. Pressure drop to the pressure relief device under flowing conditions shall be considered when determining pressure relief device location. The pressure-relief device shall not be isolated from the piping system except as permitted by NBIC Part 1, 5.3.6 e).

### 5.3.4 CAPACITY

a) The pressure relief device(s) shall have sufficient capacity to ensure that the piping is not exposed to pressures greater than that specified in the original code of construction.

b) When a non-reclosing device is installed between a pressure relief valve and the pipe, the reduction in capacity due to installation of the non-reclosing device shall be determined in accordance with the code of construction by use of a National Board certified Combination Capacity Factor (CCF). For rupture disks, if a certified combination capacity factor is not available, the capacity of the pressure relief valve shall be multiplied by 0.9 and this value used as the capacity of the combination installation.

c) The owner shall document the basis for selection of the pressure relief devices used, including capacity, and have such calculations available for review by the Jurisdiction, when required.

### 5.3.5 SET PRESSURE

a) When a single pressure relief device is used, the set pressure marked on the device shall not exceed the maximum allowable working pressure, except when allowed by the original code of construction.

b) When more than one pressure relief device is provided to obtain the required capacity, only one pressure relief device set pressure need be at or below the maximum allowable working pressure. The set pressures of the additional pressure relief devices shall be such that the pressure cannot exceed the overpressure permitted by the code of construction.

### 5.3.6 INLET AND DISCHARGE PIPING REQUIREMENTS

a) The opening through all pipes and fittings between a piping system and its pressure relief device shall have at least the area of the pressure relief device inlet. The characteristics of this upstream system shall be such that the pressure drop will not reduce the relieving capacity below that required or adversely affect the operation of the pressure relief device.

b) A non-reclosing device installed between a piping system and a pressure relief valve shall meet the requirements of NBIC Part 1, 5.3.6 a).

c) The opening in the pipe shall be designed to provide unobstructed flow between the pipe and its pressure relief device.

d) When two or more required pressure relief devices are placed on the connection, the inlet cross-sectional area of this connection shall be sized either to avoid restricting flow to the pressure relief devices or made at least equal to the combined inlet areas of the pressure relief devices connected to it. The flow characteristics of the upstream system shall satisfy the requirements of NBIC Part 1, 5.3.6 a).

e) There shall be no intervening stop valves between the piping system and its pressure relief device(s), or between the pressure relief device(s) and the point of discharge except under the following conditions:

   1) These stop valves shall be so constructed or positively controlled that the closing of the maximum number of block valves at one time will not reduce the pressure relieving capacity below the required relieving capacity;

   2) Upon specific acceptance of the Jurisdiction, when necessary for the continuous operation of processing equipment of such a complex nature that shutdown of any part is not feasible, a full area stop valve between a piping system and its pressure relief device may be provided for inspection and repair purposes only. This stop valve shall be arranged so that it can be locked or sealed open and it shall not be closed except by an authorized person who shall remain stationed there during that period of operation while the valve remains closed. The valve shall be locked or sealed in the open position before the authorized person leaves the station;

   3) A full area stop valve may be placed on the discharge side of a pressure relief device when its discharge is connected to a common header for pressure relief devices to prevent discharges from these other devices from flowing back to the first device during inspection and repair. This stop valve shall be arranged so that it can be locked or sealed open, and it shall not be closed except by an authorized person who shall remain stationed there during that period of operation while the valve remains closed. The valve shall be locked or sealed in the open position before the authorized person leaves the station. This valve shall only be used when a stop valve on the inlet side of the pressure relief device is first closed; or

   4) A piping system where the pressure originates from an outside source may have a stop valve between the system and the pressure relief device, and this valve need not be sealed open, provided it also closes off that vessel from the source of pressure.

f) Pressure relief device discharges shall be arranged such that they are not a hazard to personnel or other equipment and, when necessary, lead to a safe location for disposal of fluids being relieved.

g) Discharge lines from pressure relief devices shall be designed to facilitate drainage or be fitted with drains to prevent liquid from collecting in the discharge side of a pressure relief device. The size of discharge lines shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the pressure relief device or adversely affect the operation of the pressure relief device. It shall be as short and straight as possible and arranged to avoid undue stress on the pressure relief device.

h) The reaction forces due to discharge of pressure relief devices shall be considered in the design of the inlet and discharge piping.

i) Pressure relief devices shall be installed so they are accessible for inspection, repair, or replacement. These stop valves shall be so constructed or positively controlled that the closing of the maximum number of block valves at one time will not reduce the pressure relieving capacity below the required relieving capacity.

## 5.4 EXAMINATION, INSPECTION, AND TESTING

The owner shall ensure that all examinations, inspections, and tests required by the code of construction have been performed prior to operation.

# PART 1, SECTION 6
# INSTALLATION SUPPLEMENTS

## SUPPLEMENT 1
## INSTALLATION OF YANKEE DRYERS (ROTATING CAST-IRON PRESSURE VESSELS) WITH FINISHED SHELL OUTER SURFACES

### S1.1 SCOPE

This supplement provides guidelines for the installation of a Yankee dryer. A Yankee dryer is a pressure vessel with the following characteristics:

a) This supplement describes guidelines for the installation of a Yankee dryer. A Yankee dryer is a rotating steam-pressurized cylindrical vessel commonly used in the paper industry, and is typically made of cast iron, finished to a high surface quality, and characterized by a center shaft connecting the heads.

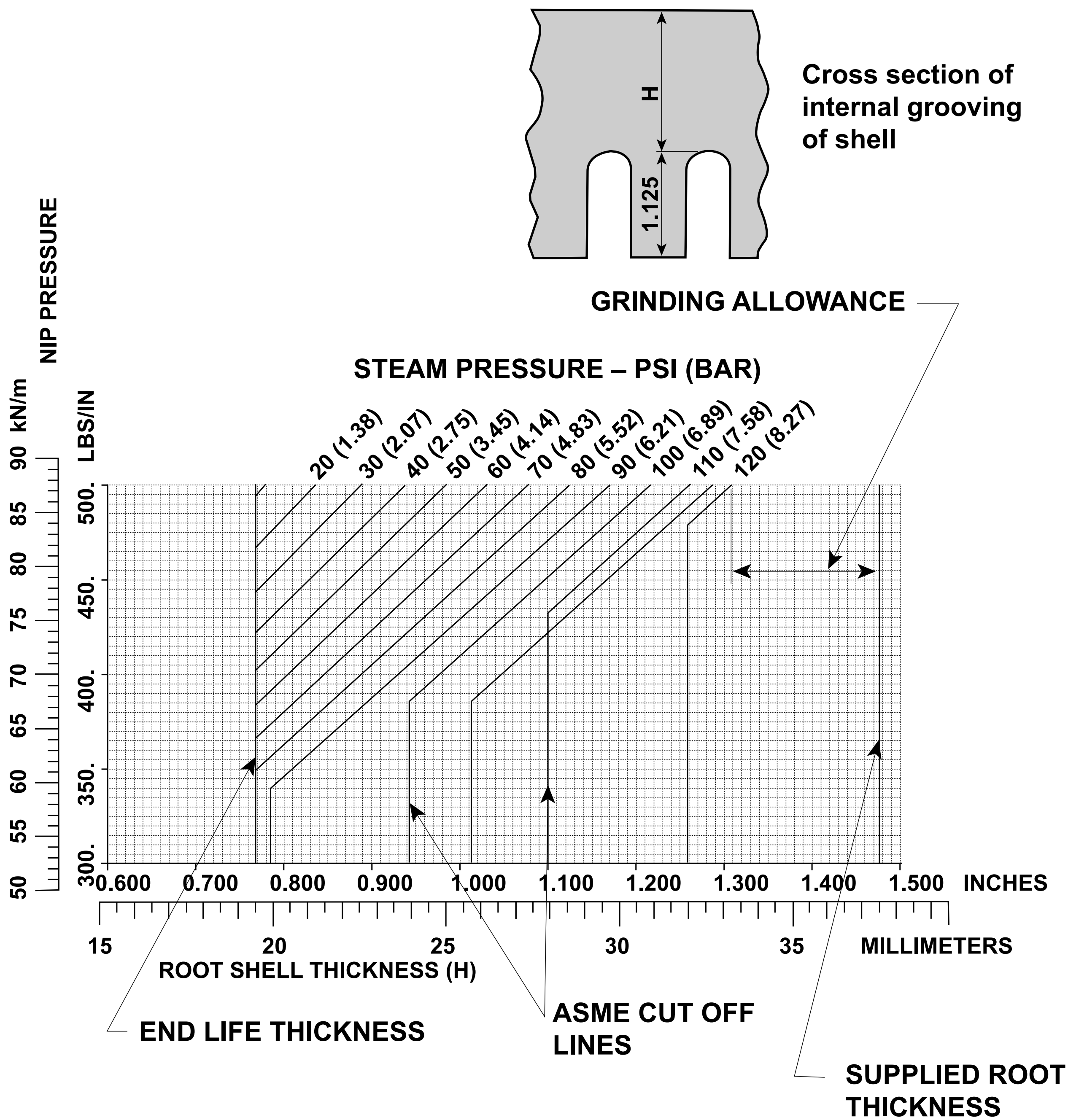
b) Yankee dryers are primarily used in the production of tissue-type paper products. When used to produce machine-glazed (MG) paper, the dryer is termed an MG cylinder. A wet paper web is pressed onto the finished dryer surface using one or two pressure (pressing) rolls. Paper is dried through a combination of mechanical dewatering by the pressure roll(s), thermal drying by the pressurized Yankee dryer, and a steam-heated or fuel-fired hood. After drying, the paper web is removed from the dryer.

c) A Yankee dryer is typically manufactured in a range of outside diameters from 8 to 23 ft. (2.4 to 7 m), widths from 8 to 28 ft. (2.4 to 8.5 m), pressurized and heated with steam up to 160 psi (1,100 kPa), and rotated at speeds up to 7,000 ft/min (2,135 m/min). Typical pressure roll loads against the Yankee dryer are up to 600 pounds per linear inch (105 kN/m). A thermal load results from the drying process due to difference in temperature between internal and external shell surfaces. The dryer has an internal system to remove steam and condensate. These vessels can weigh up to 220 tons (200 tonnes).

d) The typical Yankee dryer is an assembly of several large castings. The shell is normally a gray iron casting, in accordance with ASME designation SA-278. Shells internally may be smooth bore or ribbed. Heads, center shafts, and journals may be gray cast iron, ductile cast iron, or steel.

**FIGURE S1.1**
A TYPICAL MANUFACTURER'S "DE-RATE CURVE"

NOTE: There are several safe operating pressures for a given shell thickness.




## S1.2 ASSESSMENT OF INSTALLATION

a) The Inspector verifies that the owner or user is properly controlling the operating conditions of the dryer. The Inspector does this by reviewing the owner's comprehensive assessments of the complete installation.

b) The dryer is subjected to a variety of loads over its life. Some of the loads exist individually, while others are combined. Considerations of all the loads that can exist on a Yankee dryer are required to determine the maximum allowable operating parameters. There are four loads that combine during normal operation to create the maximum operating stresses, usually on the outside surface of the shell at the axial center line. These loads and the associated protection devices provided to limit these loads are:

1) Pressure load due to internal steam pressure. Overpressure protection is provided by a safety relief valve;

2) Inertial load due to dryer rotation. Over-speed protection is usually provided by an alarm that indicates higher-than-allowable machine speed;

3) Thermal gradient load due to the drying of the web. Protection against unusual drying loads is usually provided by logic controls on the machine, primarily to detect a "sheet-off" condition that changes the thermal load on the shell exterior from being cooled by the tissue sheet to being heated by the hot air from the hood; and

4) Pressure roll load (line or nip load) due to pressing the wet web onto the dryer. Overload protection is usually provided by a control valve that limits the pneumatic or hydraulic forces on the roll loading arms such that the resultant nip load does not exceed the allowable operating nip load.

c) Steam pressure, inertial, and thermal gradient loads impose steady-state stresses. These stresses typically change when the dryer shell thickness (effective thickness for ribbed dryers) is reduced to restore a paper-making surface, the grade of tissue is changed or speed of the dryer is changed.

d) The pressure roll(s) load imposes an alternating stress on the shell face. The resulting maximum stress is dependent on the magnitude of the alternating and steady-state stresses.

e) Section VIII, Division 1, of the ASME Code only provides specific requirements for the analysis of pressure loads. Although the Code requires analysis of other loads, no specific guidance for thermal, inertial, or pressure roll loads is provided. Hence, additional criteria must be applied by the manufacturer to account for all the steady-state and alternating stresses.

f) To maintain product quality, the dryer surface is periodically refurbished by grinding. This results in shell thickness reduction. Therefore, the manufacturer does not provide a single set of maximum allowable operating parameters relating steam pressure, rotational speed, and pressure roll load for a single design shell thickness. The manufacturer, or another qualified source acceptable to the Inspector, instead provides a series of curves that graphically defines these maximum allowable operating parameters across a range of shell thicknesses. This document is known as the "De-rate Curve." (See NBIC Part 1, Figure S1.1).

g) In addition to the loads on the Yankee dryer due to operation, other nonstandard load events can occur during shipment and installation into the paper machine. These nonstandard load events should be recorded in an incident log. Examples of nonstandard load events include:

1) Damage to the protective packaging of the Yankee dryer during transport;

2) Scratches, gouges, dents in the Yankee dryer shell during packaging removal or installation into the paper machine;

3) Excessive heating of the Yankee dryer shell during the installation and testing of the hot air hood. If the hot air hood will be generating air that is hotter than the Yankee dryer shell material's maximum allowable working temperature (MAWT), then temperature sensors should be installed to monitor and record the Yankee dryer shell temperature during the hood testing; and

4) Impact load from improperly installed rolls, wires, nuts, dropped wrenches, etc., that may travel through the pressure roll nip causing external impact loads on the Yankee dryer shell.

h) If nonstandard load events (incidents) have occurred during installation, then the Inspector should ensure that an appropriate assessment of the structural integrity of the Yankee dryer has been performed. For additional details see Yankee dryer supplements in NBIC Part 2 and Part 3.

## S1.3 DETERMINATION OF ALLOWABLE OPERATING PARAMETERS

a) A Yankee dryer is designed and intended to have its shell thickness reduced over the life of the vessel through routine grinding and machining. The Yankee dryer shell is ground or machined on the outside surface to restore the quality or shape of the papermaking surface essential to the manufacturing of tissue or other paper products.

b) Design documentation, called the “De-rate Curve,” is required and dictates the maximum allowable operating parameters as shell thickness is reduced (see NBIC Part 1, Figure S1.1). Calculations, used to determine those parameters, are in accordance with ASME Code requirements for primary membrane stress by the vessel manufacturer or design criteria based on relevant stress categories, e.g., fatigue and maximum principal stress. Calculation of these parameters requires that the respective stresses, resulting from the imposed loads, be compared to the appropriate material strength properties. Hence, knowledge of the applied stresses in the shell and the tensile and fatigue properties of the material are essential.

c) Yankee dryers are subjected to a variety of loads that create several categories of stress. Yankee dryers are designed such that the stress of greatest concern occurs at the centerline of the shell.

1) Steam Pressure Load — The internal steam pressure is one of the principal design loads applied to the Yankee dryer. The steam pressure expands the shell radially, causing a predominately circumferential membrane tensile stress. Because the shell is constrained radially by the heads at either end of the shell, the steam pressure also causes a primary bending stress in the vicinity of the head-to-shell joint. The ends of the shell are in tension on the inside and compression on the outside due to the steam pressure. The steam pressure also causes a bending stress in the heads.

2) Inertia Load — The rotation of the Yankee dryer causes a circumferential membrane stress in the shell similar to that caused by the pressure load. This stress is included in the design of the shell and increases with dryer diameter and speed.

3) Thermal Load — The wet sheet, applied to the shell, causes the outside surface to cool and creates a thermal gradient through the shell wall. This thermal gradient results in the outside surface being in tension and the inside surface in compression. With this cooling, the average shell temperature is less than the head temperature, which creates bending stresses on the ends of the shell and in the heads. The ends of the shell are in tension on the outside and compression on the inside.

a. Other thermal loadings also occur on a Yankee dryer. The use of full-width showers for a variety of papermaking purposes affects the shell similar to a wet sheet. The use of edge sprays produce high bending stress in the ends of the shell due to the mechanical restraint of the heads.

b. Warm-up, cool-down, hot air impingement from the hood, moisture profiling devices, fire fighting, and wash-up can all produce non-uniform thermal stresses in the pressure-retaining parts of the Yankee dryer. Heating or cooling different portions of the Yankee dryer at different rates causes these non-uniform stresses.

4) Nip Load — The nip load from the contacting pressure roll(s) results in an alternating, high cycle, bending stress in the shell. This stress is greatest at the centerline of the shell. The load of the pressure roll deflects the shell radially inward causing a circumferential compressive stress on the outside surface and a tensile stress on the inside. Because the shell has been deflected inward at the pressure roll nip, it bulges outward about 30 degrees on each side of the nip. The outward bulge causes a tensile stress on the outside shell surface at that location and a corresponding

compressive stress on the inside. Since the shell is passing under the pressure roll, its surface is subjected to an alternating load every revolution.

## S1.4 ASME CODE PRIMARY MEMBRANE STRESS CRITERIA

a) Yankee dryers are typically designed and fabricated in accordance with ASME Section VIII, Division 1, The maximum allowable stress for cast iron is specified in UCI-23 and UG-22 of the ASME Code.

b) ASME Section VIII, Division 1, requires design stresses to be calculated such that any combination of loading expected to occur simultaneously during normal operation of the Yankee dryer will not result in a general primary stress exceeding the maximum allowable stress value of the material. In the ASME Code, the combination of loading resulting in the primary membrane stress in the shell is interpreted to be only composed of the circumferential stress from steam pressure. Sometimes, the stress from the inertial loading is included in this consideration.

c) In ASME Section VIII, Division 1, it is very important to note that no formulas are given for determining the stresses from thermal operating loads and pressure roll nip load(s). Hence, additional criteria need to be incorporated to establish the maximum allowable operating parameters of the Yankee dryer. Two such additional criteria are based upon the maximum principal and fatigue stress.

   1) Maximum Principal Stress Criteria

      The maximum principal stress in a Yankee dryer shell is the sum of the stresses that are simultaneously applied to the shell and is always aligned in the circumferential direction. The purpose of these criteria is to recognize the paper making application of the Yankee dryer and to prevent catastrophic failure by including all stresses. The ASME Code does not provide specific formulas for the full array of Yankee dryer shell stresses encountered in tissue making.

   2) Fatigue Stress Criteria

      Under normal operation, the stresses due to the steam pressure, inertial and thermal operating loads are considered to be steady-state stresses. When acting simultaneously, the sum of these stresses must be judged against the cyclic, or alternating, stress due to the pressure roll nip load. Fatigue stress criteria limit the alternating stress at a given mean stress using fatigue failure criteria described by the Goodman or Smith Diagram. The purpose of this limitation is to prevent crack initiation in the outside wall due to the combination of stresses. As the thickness of the shell is reduced, one or more of these criteria will control the various operating parameters.

## S1.5 PRESSURE TESTING

a) Water pressure testing in the field is not recommended because of the large size of Yankee dryers and the resulting combined weight of the Yankee dryer and the water used in the testing. This combined weight can lead to support structure overload. Several failures of Yankee dryers have occurred during field pressure testing using water. If this test must occur, the following review is recommended:

   1) The testing area should be evaluated for maximum allowable loading, assuming the weight of the Yankee dryer, the weight of the water filling the Yankee dryer, and the weight of the support structure used to hold the Yankee dryer during the test; and

   2) The manufacturer should be contacted to provide information on building the Yankee dryer support structure for the water pressure test. Typically, the Yankee dryer is supported on saddles that contact the Yankee dryer shell at each end near the head-to-shell joint. The manufacturer can provide information on saddle sizing and location so that the Yankee dryer is properly supported for the test.

b) When pressure testing is desired to evaluate the Yankee dryer for fitness for service, an alternative to water pressure testing is acoustic emission testing using steam or air pressure. Typically, the test pressure used is the operating pressure. Caution needs to be exercised to ensure personnel safety. Entry to the test area needs to be controlled and all personnel need to maintain a safe distance from the Yankee dryer during the test. The steam or air test pressure should never exceed the maximum allowable working pressure (MAWP) of the Yankee dryer.

## S1.6 NONDESTRUCTIVE EXAMINATION

a) Nondestructive examination (NDE) methods should be implemented by individuals qualified and experienced with the material to be tested using written NDE procedures. For Yankee dryers, cast iron knowledge and experience are essential.

b) Typical nondestructive examination methods should be employed to determine indication length, depth, and orientation (sizing) of discontinuities in Yankee dryers. Magnetic Particle, specifically the wet fluorescent method, and Dye Penetrant methods are applicable in the evaluation of surface-breaking indications. Ultrasound testing is the standard method for evaluation of surface-breaking and embedded indications. Radiographic methods are useful in the evaluation of embedded indications. Acoustic Emmission Testing can be used to locate and determine if a linear indication is active, e.g., propagating crack. Metallographic Analysis is useful in differentiating between original casting discontinuities and cracks.

c) When nondestructive testing produces an indication, the indication is subject to interpretation as false, relevant, or nonrelevant. If it has been interpreted as relevant, the necessary subsequent evaluation will result in a decision to accept, repair, replace, monitor, or adjust the maximum allowable operating parameters.