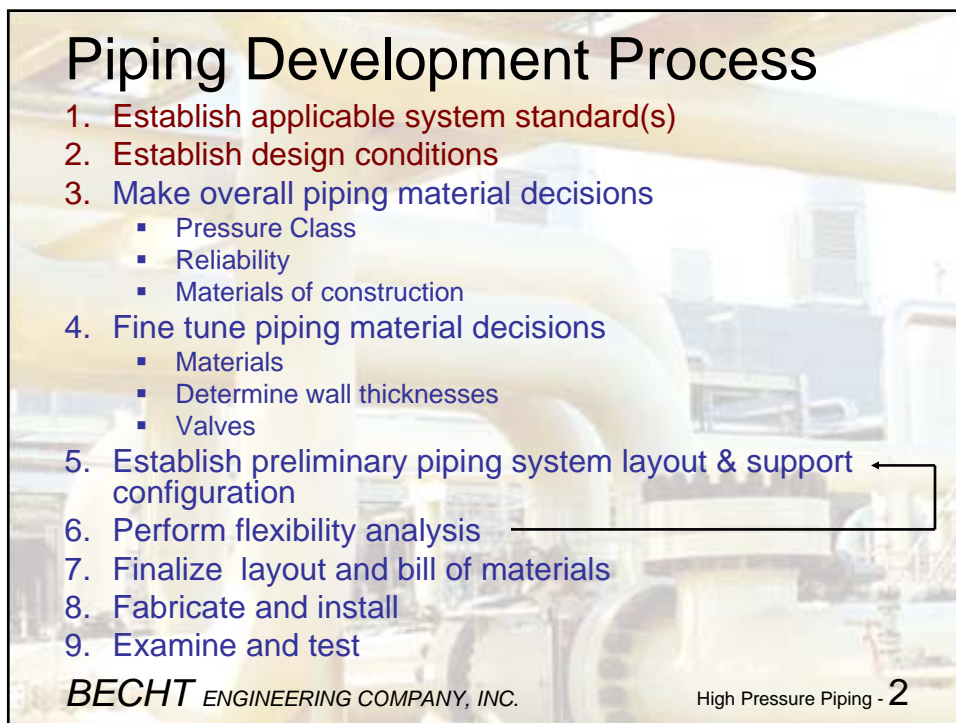


# ASME B31.3 Process Piping

Charles Becht IV, PhD, PE  
Don Frikken, PE  
Instructors

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## Piping Development Process

1. Establish applicable system standard(s)
2. Establish design conditions
3. Make overall piping material decisions
  - Pressure Class
  - Reliability
  - Materials of construction
4. Fine tune piping material decisions
  - Materials
  - Determine wall thicknesses
  - Valves
5. Establish preliminary piping system layout & support configuration
6. Perform flexibility analysis
7. Finalize layout and bill of materials
8. Fabricate and install
9. Examine and test

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## 17. High Pressure Piping

- General
- Materials
- Pressure Design
- Limitations
- Fabrication
- Examination
- Testing



(Autoclave Engineers)

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High Pressure Piping - 3

The Material in This Section is  
Addressed by B31.3 in:

Chapter IX - High Pressure Piping

Appendix K - Allowable Stresses for High  
Pressure Piping

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High Pressure Piping - 4

## General

**High Pressure:** A service for which the owner specifies the use of Chapter IX [of B31.3] for piping design and construction... considered to be in excess of Class 2500 (6000 psi, 42 MPa).

There are no specified pressure limitations for application of these rules.  
[K300(a)]

## General

- Most applications are in the range of 20,000 psi (150 MPa) and higher
- Nonmetallic piping is excluded
- No provisions are made for Category M fluid service
- The temperature is required to be below the creep range
- Allowances for variations in pressure and temperature are not permitted

## Materials

- Allowable stress for materials other than bolting
  - 2/3 of specified minimum yield strength ( $S_Y$ )
  - 2/3 of yield strength at temperature; except for austenitic stainless steels and nickel alloys with similar behavior, 90% of yield strength at temperature

Material	Base Code (ksi)	High Pressure (ksi)	Base Code (MPa)	High Pressure (MPa)
A106 Gr B	20.0	23.3	138	161
API 5L X80	30.0	53.3	207	368

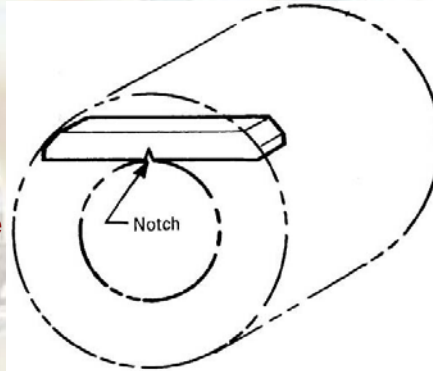
## Materials

- Castings and welded components are required to be such that the quality factors are equal to 1.0
- Conformance of materials to the product analysis chemical requirements of the applicable specification shall be verified.
- Cast irons are not permitted
- Zinc coated materials are not permitted, nor are zinc coated materials permitted to be welded to pressure containing components

## Materials

### Impact Test Requirements

- Impact testing is required for all materials from which a suitable test specimen can be machined
- The impact test temperature shall be no higher than the lowest temperature at which the piping is subjected to a stress greater than 6 ksi (41 MPa)...lower if subsize specimens are required
- Minimum acceptable impact values are higher than for the base code



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High Pressure Piping - 9

## Pressure Design – Straight Pipe

$$t = (D/2) [1 - \exp(-1.155P/S)]$$

Where:

t = pressure design thickness

D = outside diameter of pipe

P = design pressure

S = stress value for material from

Appendix K



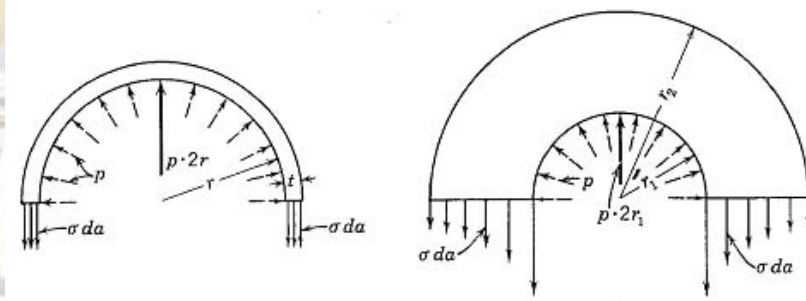
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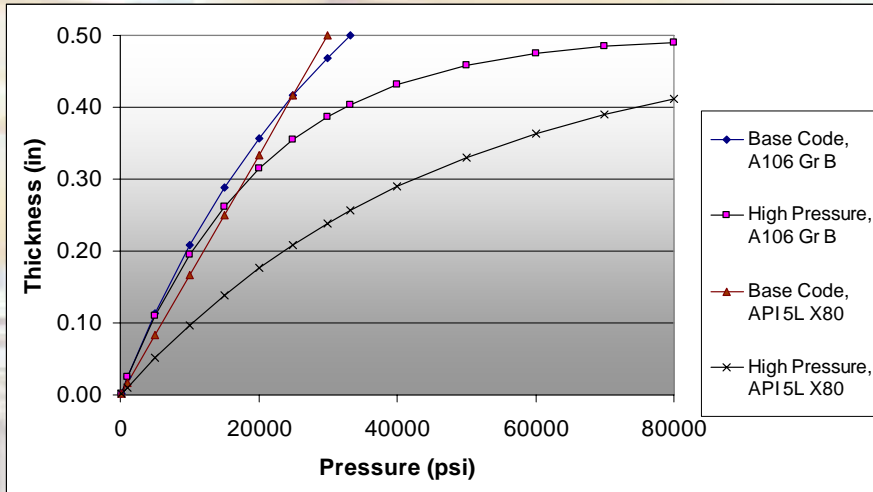
High Pressure Piping - 10

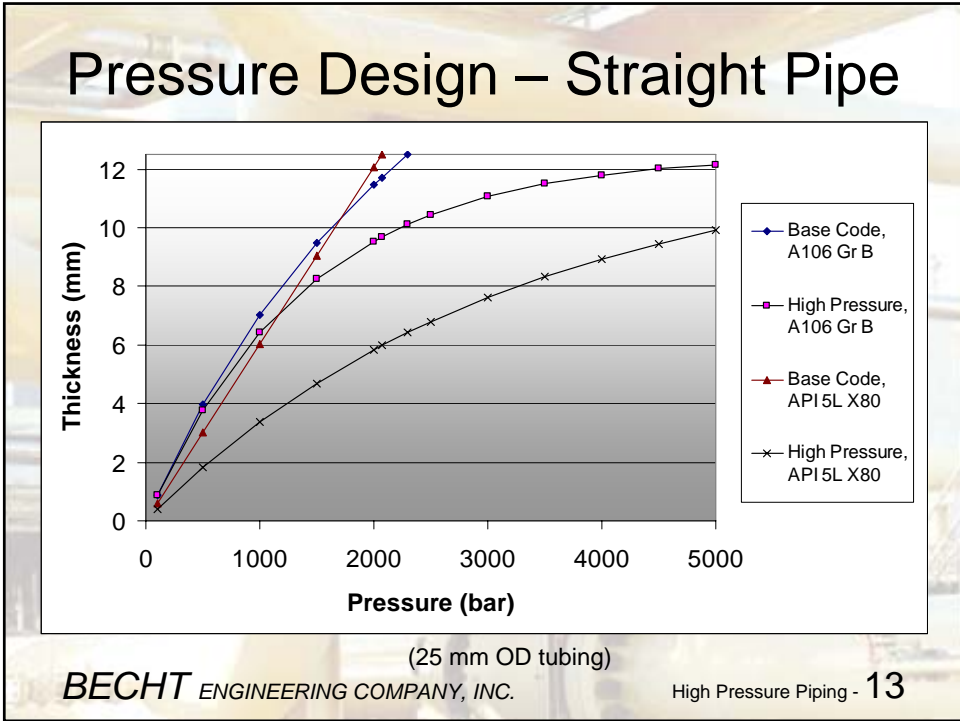
# Pressure Design – Straight Pipe

- The equation is based on through thickness yielding pressure as a basis for design
- The equation provides a factor of two on through thickness yielding



# Pressure Design – Straight Pipe





## Pressure Design

Thread depth need not be subtracted from the pipe wall thickness when

- Thread depth does not exceed 20% of the wall thickness
- $D/d$  is greater than 1.1
- The internally threaded attachment provides adequate reinforcement
- The thread undercut area does not extend beyond the reinforcement by a distance greater than the pipe wall thickness

**Series KCGL**  
Pressures to 60,000 psi (4137 bar)  
(Autoclave Engineers)

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## Pressure Design [K304.7.2]

Components for which there are no specific rules require:

- Calculations consistent with the design philosophy of Chapter IX, and
- Substantiation of the calculations by
  - Extensive successful experience
  - Performance testing, or
  - Finite element stress analysis
- Interpolation between sizes & thicknesses allowed

## Pressure Design

### Fatigue Analysis

- Fatigue analysis in accordance with ASME B&PV Code, Section VIII, Div. 2 is required
- Pressure is the primary load, but alternating sustained loads and displacement loads must also be included
- High stresses at the inner surface of the pipe wall and stress concentrations must be considered
- An inelastic analysis is required if the stress on the inside surface of the pipe exceeds three times the allowable stress (twice yield)



## Pressure Design

### Fatigue Analysis

- Fatigue life may be demonstrated by destructive testing when the owner approves
- Fatigue life beyond that calculated via the Section VIII, Div. 2 method may be applied when
  - surface treatments or
  - prestressing methodsare used, and the component is qualified by
  - extensive successful service or
  - performance testingin accordance with K304.7.2

## Limitations

### Not permitted

- Miter bends
- Fabricated branches
- Corrugated and creased bends
- Laps other than forged
- Slip-on flanges

## Limitations

### Joints Not permitted

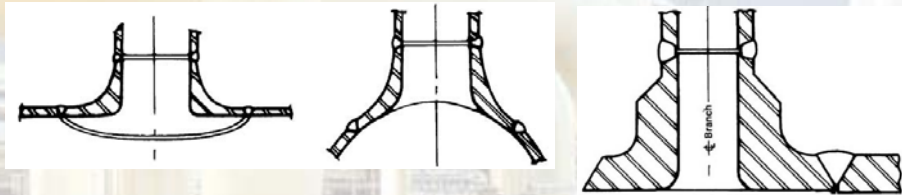
- Ordinary threaded, except for instrumentation up to NPS ½
- Socket welding
- Expanded
- Solder
- Compression and flared tubing
- Caulked
- Bell type
- Adhesive

## Fabrication

- Welder qualification is like for the base Code, except
  - Impact tests are required for all procedure and performance qualifications
  - More testing is required for weld procedure and performance qualifications
  - Performance and procedure qualification by others is not permitted

## Fabrication

- Seal welds are not permitted
- Welded branch construction must provide for 100% interpretable radiographic examination



## Examination Requirements - VT

<b>Metallic Piping</b>	<b>Normal</b>	<b>High Pressure</b>
Materials & components	Random to extent needed to satisfy the examiner	100%
Fabrication, including welds	5% Random	100%
Longitudinal welds	100%	100%
Bolted, threaded & other joints	Random to extent needed..., except 100% for pneumatic test	100%, threads to be examined for finish and fit, and compliance with applicable standard
Supports, alignment, erected piping	Random	100%

## Examination Requirements - Other

<b>Metallic Piping</b>	<b>Normal</b>	<b>High Pressure</b>
Circumferential groove welds	5% Random RT or UT	100% RT
Longitudinal welds		100% RT
Branch connection welds		100% RT

- Neither ultrasonic examination nor in-process examination may be substituted for radiographic examination.
- Acceptance criteria are more stringent than the base Code

## Testing

- A hydrostatic or a pneumatic test at 1.5 times the design pressure corrected for temperature is required
- Protection of people and property from missile fragments, shock waves and other consequences of failure must be provided
- A leak test of the installed piping at 1.1 times the design pressure is required unless the main leak test was done on the installed piping
- For all welded systems, the closing weld may be tested at 1.1 times the design pressure