PVP 2009-77847
Summary Review of Updated ASME PCC-1 20XX "Guideline For Pressure Boundary Bolted Flanged Joint Assembly"

Jerry Waterland
VSP Technologies, Inc.

Jim Payne
JPAC, Inc.

Presented To:
ASME PVP-2009
Prague, Czech Republic
July 28, 2009

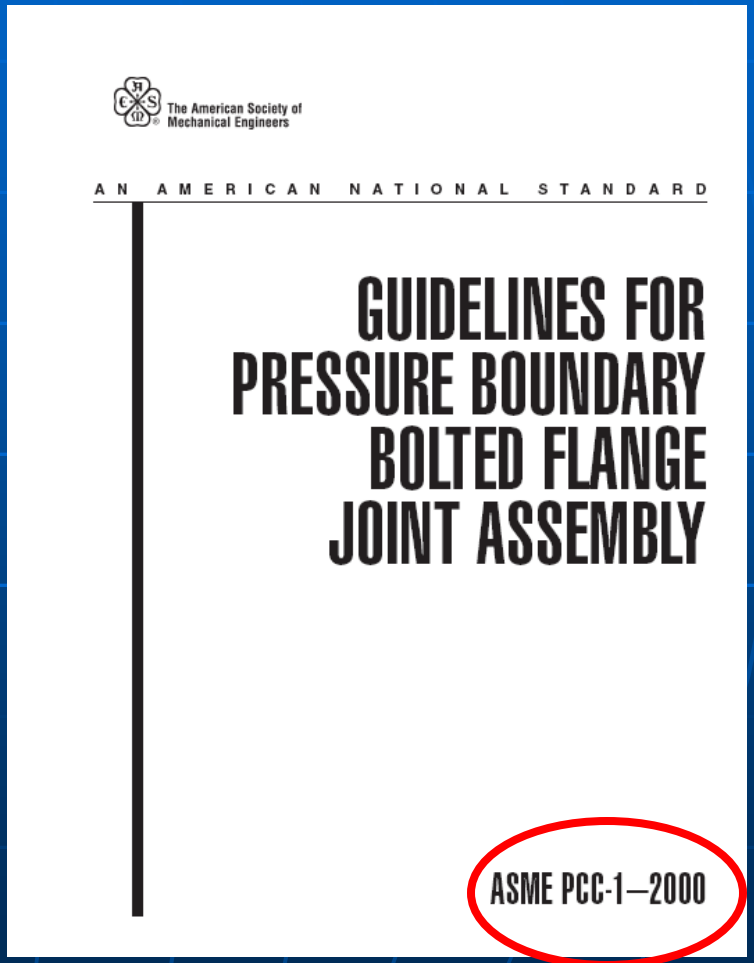
Background

- ASME Post Construction Committee

  PCC-1-2000 Update Project

- New Sub-Committee on Flange Joint Assembly

- Updates Include:
  - Expanded Guidance/Best Practices
  - Updated & New Appendices



High Impact Appendices

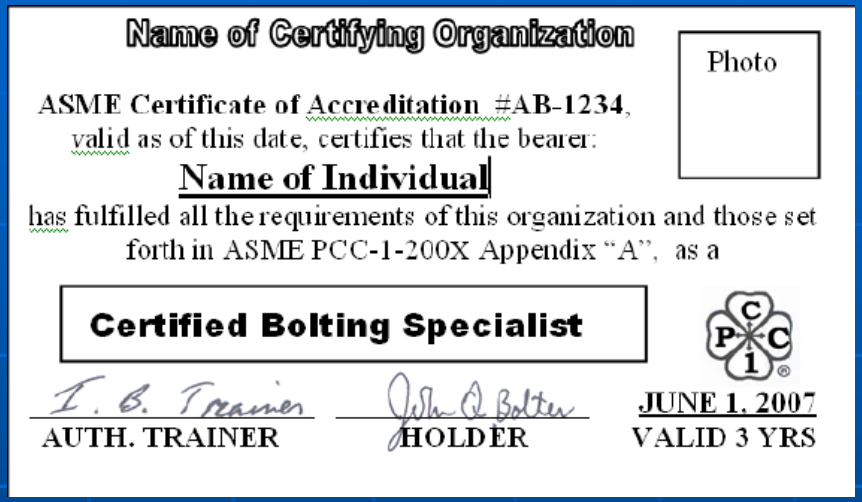
- **Appendix A:**

  Training, Qualification and Certification of Joint Assembly Personnel

  - "Guidelines for uniform criteria for training, qualifying and certifying bolted joint assembly personnel"
  - Certification levels:
    - Certified Bolting Specialist
    - Certified Senior Bolting Specialist
    - Certified Bolting Specialist Instructors
  - Requirements for Accreditation of Certifying Organizations

Appendix A (Cont.)

- Credentials



Name of Certifying Organization

Photo

ASME Certificate of Accreditation #AB-1234, valid as of this date, certifies that the bearer:

Name of Individual

has fulfilled all the requirements of this organization and those set forth in ASME PCC-1-200X Appendix "A", as a

Certified Bolting Specialist

I. B. Trainer — AUTH. TRAINER

John Q Bolter — HOLDER

JUNE 1, 2007 — VALID 3 YRS

- Classroom instruction
- Practical flange assembly examination
- Written examination

Appendix A (Cont.)

- Bolting Specialist: **Classroom** Instruction/Training Fundamentals
  - General health and safety precautions
  - Equipment requirements
  - Principles of bolt elongation, bolt load and bolt stress
  - Functionality of gasket and seal
  - Gasket types and their limitations
  - Bolt types and their limitations
  - Identification of correct joint components
  - Manual torque wrench joint tightening
  - Importance of thread lubricants
  - Techniques for load control
  - Calibration and maintenance of bolt tightening equipment
  - Inspection and reporting of defects and faults
  - Preparing a joint for closure
  - Gasket handling, preparation, and installation
  - Safe joint dis-assembly and assembly
  - Correct use of additional joint components (washers, etc.)
  - Joint assembly QA procedures, certification and records
  - Joint dis-assembly

Appendix A (Cont.)

- Bolting Specialist: Additional Training Endorsements
  - Piping specific training (Required)
  - Powered Equipment Endorsement
  - Heat Exchanger Endorsement
  - Special Joint Endorsements

Appendix A (Cont.)

- Bolting Specialist: **Practical Flange Assembly Demonstrations** and Examination
  - Importance of gasket placement/alignment
  - Importance of joint alignment
  - Importance of bolt assembly patterns
  - Importance of bolt assembly pattern and correct gasket selection
  - Reaction of different gasket types to standard tightening procedure
  - Demonstration of effect of lubricants
- Re-Certification exam every three years

High Impact Appendices

- **Appendix D:**

  Guidelines for Allowable Gasket Contact Surface Flatness and Defect Depth

Table D-1 Flange Seating Face Flatness Tolerances (inches)

	Hard Gaskets	Soft Gaskets
Acceptable Variation in Circumferential Flange Seating Surface Flatness	T1 < 0.006" in.	T1 < 0.01" in.
Acceptable Variation in Radial (across surface) Flange Seating Surface Flatness	T2 < 0.006" in.	T2 < 0.01" in.
Maximum Acceptable Pass-Partition surface height vs. flange face	- 0.01" in. < P < 0.0" in.	- 0.02" in. < P < 0.0" in.

High Impact Appendices

- **Appendix D:**

  Guidelines for Allowable Gasket Contact Surface Flatness and Defect Depth

Table D-2 Allowable Defect Depth vs. Width Across Face (inches)

	Hard Faced Gaskets	Soft Faced Gaskets
$r_d < w/4$	< 0.03" in.	< 0.05" in.
$w/4 < r_d < w/2$	< 0.01" in.	< 0.03" in.
$w/2 < r_d < 3w/4$	Not Allowed	< 0.005" in.
$r_d > 3w/4$	Not Allowed	Not Allowed

High Impact Appendices

- **Appendix D:**

  Guidelines for Allowable Gasket Contact Surface Flatness and Defect Depth

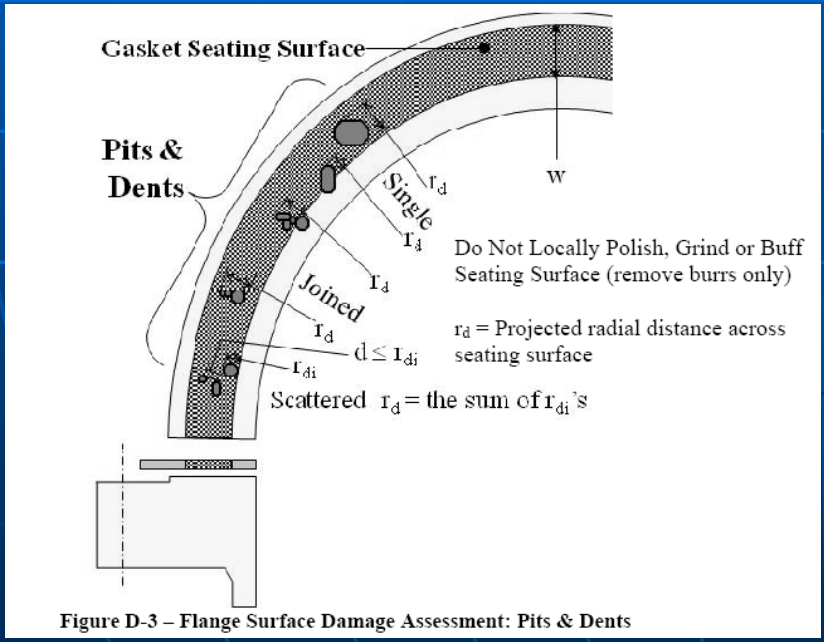


Figure D-3 – Flange Surface Damage Assessment: Pits & Dents

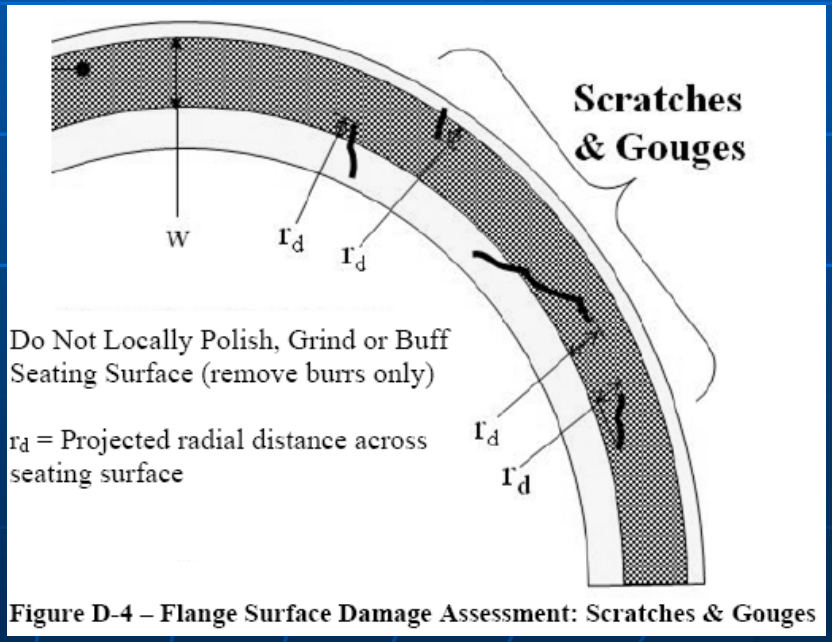
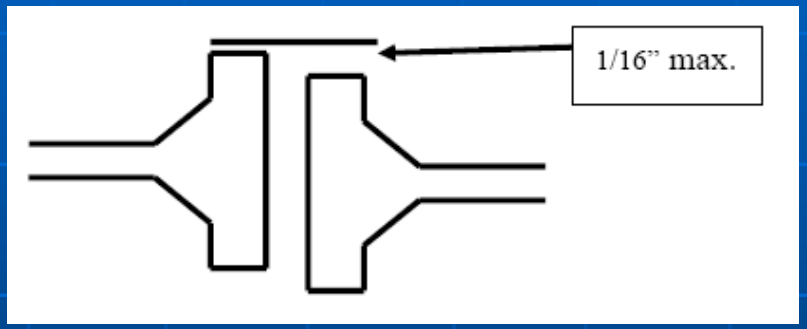


Figure D-4 – Flange Surface Damage Assessment: Scratches & Gouges

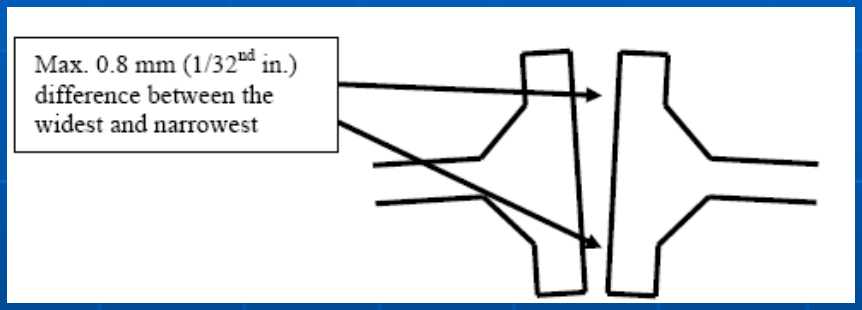
High Impact Appendices

- **Appendix E:**

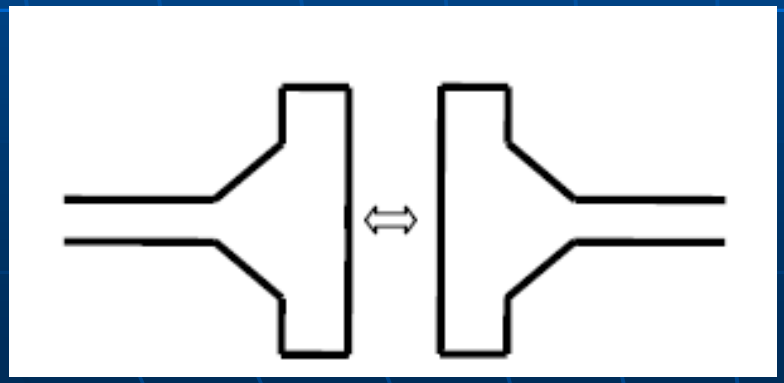
  Flange Joint Alignment Guidelines



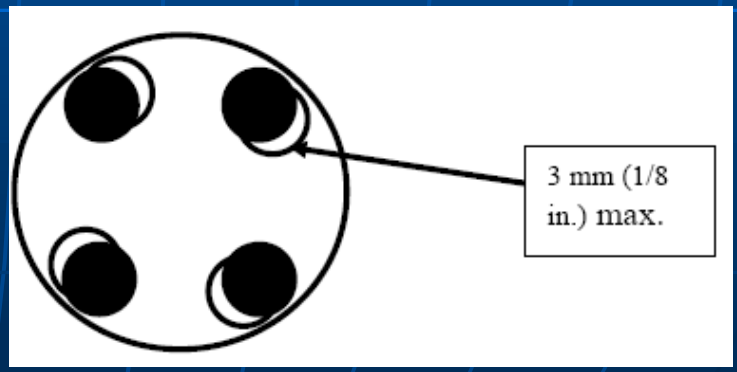
Centerline



Parallelism



Flange Face Gap



Rotational

High Impact Appendices

- **Appendix F:**

  Alternatives to Legacy Tightening Sequence/Pattern

1. Five alternative (non-Legacy) assembly procedures detailed

2. Guidelines for developing and qualifying additional alternative assembly procedures

High Impact Appendices

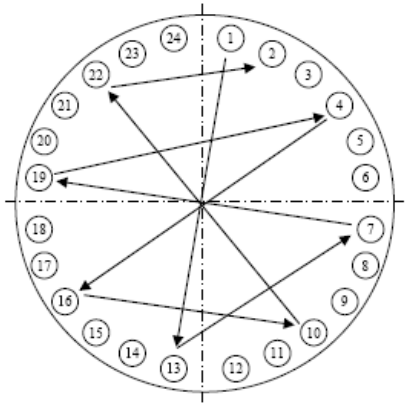
- **Appendix F:**

  Alternatives to Legacy Tightening Sequence/Pattern

ALTERNATIVE ASSEMBLY PATTERN #1

This pattern uses the same pattern as the Legacy method, however the stress levels are increased more rapidly, which allows fewer pattern passes to be performed and less overall effort. This method has been successfully applied in limited applications across the full range of gaskets and joint configurations.

Pass #1a: Proceed in the pattern outlined below and tighten the first four bolts at 20-30% of Target Torque
Pass #1b~~2~~: Tighten the next four bolts at 50-70% of final load
Pass #1c & 2~~3~~: Tighten all subsequent bolts at 100% of final load until all pattern passes are complete
Pass #3 onward~~4~~: Tighten in circular passes until the nuts no longer turn



24 Bolt Example:

Pass 1a – 20-30% of Target Torque:
1,13,7,19

Pass 1b – 50-70% of Target Torque:
4,16,10,22

Pass 1c - 100% of Target Torque:
2,14,8,20 - 5,17,11,23 - 3,15,9,21 - 6,18,12,24

Pass 2 (If 2nd pattern pass specified) - 100% of Target Torque
1,13,7,19 - 4,16,10,22 - 2,14,8,20 - 5,17,11,23 - 3,15,9,21 - 6,18,12,24

Pass 3 ~~& Subsequent~~onward - 100% of Target Torque, in ~~rotational~~ circular pattern, until nuts do not turn.
1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24 - 1,2,3, etc….

Detailed Instructions

High Impact Appendices

- **Appendix F:**

  Alternatives to Legacy Tightening Sequence/Pattern

Alternative Pattern #1 **MODIFIED ~~STAR~~ LEGACY PATTERN** Percent Of Final Torque	The same as the Legacy ~~method~~pattern, however the stress levels are increased more rapidly, allowing fewer pattern passes to be performed and less overall effort. This method has been successfully applied in limited applications across the full range of gaskets and joint configurations.	1st Four to Six Bolts, Star Pattern 30%	Next Four to Six Bolts, Star Pattern 70%	Remaining Bolts, Star Pattern 100%	All Bolts, Star Pattern 100%	All Bolts, Circular~~Rotational~~ Pattern, Until No Further Nut Movement 100%	For soft gaskets[1], a minimum of 2 pattern passes are required. For hard gaskets[2] a minimum of one pattern pass is required. For problematic joints, it is recommended that an additional pattern pass be completed above the minimum required.

Summary Instructions

High Impact Appendices

- **Appendix F:**

  Alternatives to Legacy Tightening Sequence/Pattern

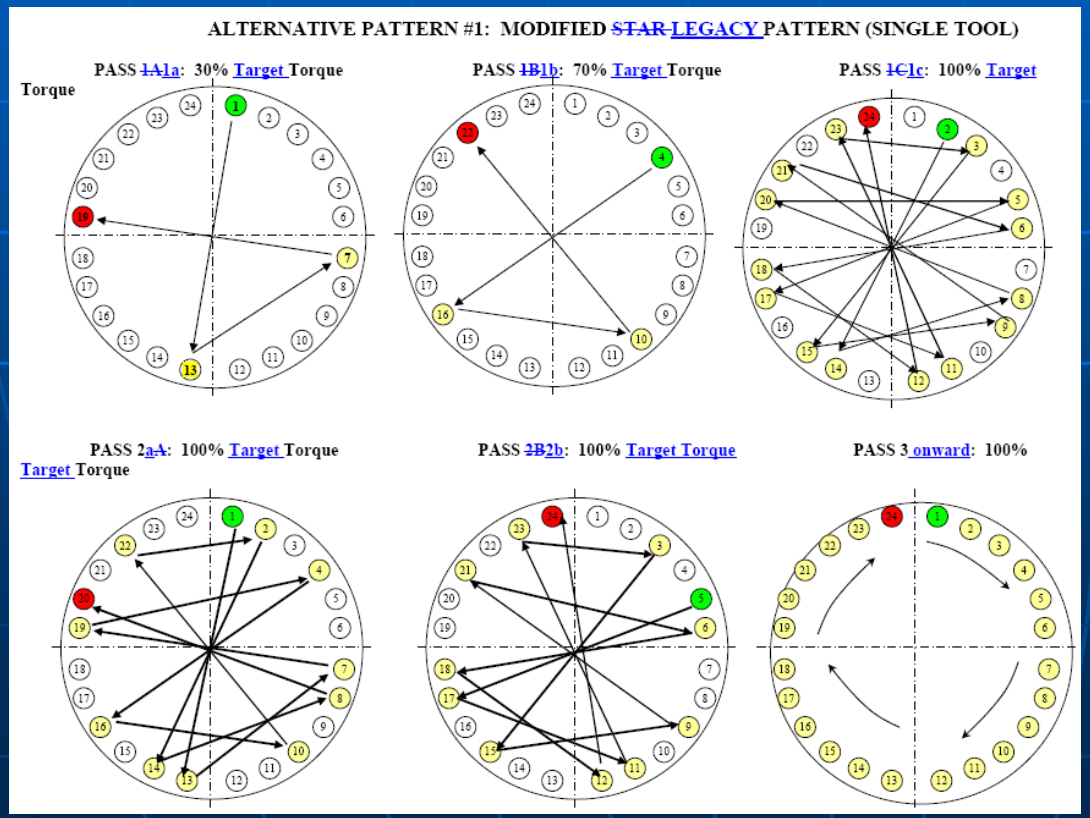


Diagram Examples

High Impact Appendices

- **Appendix M:**
  Washer Usage Guidance

Washer usage guidance

Material Type	Single-Use NOTE (1)	Reuse NOTE(2)
1	425 deg C (800 deg F)	205 deg C (400 deg F)
4	540 deg C (1000 deg F)	400 deg C (750 deg F)
5	650 deg C (1200 deg F)	425 deg C (800 deg F)
6	815 deg C (1500 deg F)	550 deg C (1025 deg F)

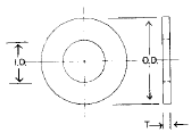
(1) Single-use service temperature limits are based on replacement whenever the existing washer has been exposed to temperature in excess of the corresponding reuse limit.
(2) Reuse service temperature limits are based on metallurgical concerns (softening) for the washer material.

Purchase specification for through-hardened washers

Dimensional requirements

Dimensional tolerances

TABLE M-4 Dimensional Requirements for ~~Inch~~ U.S. Customary Washers NOTE(1)



Nominal Size, (in)	Outside Diameter (OD)		Inside Diameter (ID)		Thickness (T)	
	(mm)	(in.)	(mm)	(in.)	(mm)	(in.)
1/2	27.0	1.063	14.3	0.563	3.2	0.125
5/8	33.4	1.313	17.5	0.688	4.0	0.156
3/4	38.1	1.500	20.7	0.813	4.8	0.188
7/8	43.6	1.718	23.8	0.938	5.6	0.219
1	50.0	1.968	27.0	1.063	6.4	0.250
1 1/8	54.8	2.156	30.2	1.188	6.4	0.250
1 1/4	60.3	2.375	33.4	1.313	6.4	0.250
1 3/8	65.9	2.593	36.5	1.438	6.4	0.250

High Impact Appendices

- **Appendix O:**

  Assembly Bolt Stress Determination

Method for establishing assembly bolt stresses considering:

- Sufficient assembly and operating gasket stress
- Maximum gasket stress
- Maximum bolt stress
- Permanent flange deformation

1. Simple Approach
2. Joint Component Approach

High Impact Appendices

- **Appendix O:**

  Assembly Bolt Stress Determination

Example Analysis:

Table O-9 – Example Bolt Stress and Torque Tables for Weldneck Flanges, SA-105 & SA193-B7 Material, Spiral Wound with inner ring.

Example Limits Used in the Analysis:

- Sb_{min} = 35 ksi
- Sb_{max} = 75 ksi
- Sb_{sel} = 30 ksi
- Sg_{max} = 40 ksi
- $Sg_{min\text{-}S}$ = 12.5 ksi
- $Sg_{min\text{-}O}$ = 6 ksi
- θg_{max} = 1.0°
- Sf_{max} from Table O-3

= Limited by Min. Bolt Stress

= Limited by Max. Bolt Stress

= Limited by Max. Gasket Stress

= Limited by Max. Flange Stress

	Min. Calculated Bolt Stress (ksi)					
	150	300	600	900	1500	2500
2	75	56	56	43	43	35
2.5	75	44	44	40	40	35
3	75	63	64	60	38	35
4	75	75	75	49	42	35
5	75	75	75	48	36	35
6	75	75	74	56	38	35
8	75	75	75	44	35	35
10	75	75	62	40	35	35
12	75	75	66	49	35	35
14	75	63	54	44	35	
16	75	63	58	42	35	
18	75	68	62	45	35	
20	75	74	57	38	35	
24	75	68	50	35	35	
26	37	37	41	35		
28	35	37	38	35		
30	37	42	41	35		
32	35	37	35	35		
34	35	42	36	35		
36	35	37	35	35		
38	37	75	39	35		
40	35	68	36	35		
42	37	71	35	35		
44	35	68	35	35		
46	37	69	35	35		
48	37	63	35	35		

High Impact Appendices

- **Appendix P:**

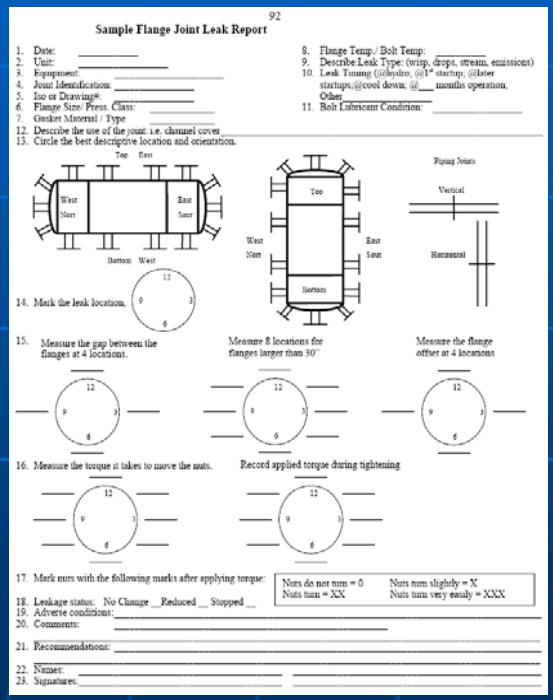
  Guidance On Troubleshooting
  Flanged Joint Leakage Incidents

- Investigative and Diagnostic Evaluation Guide

- Checklist of Flange Design and Acceptable Practice Considerations

- Leakage Problems and Potential Solutions

LHT - Leak during hydro-test.
LIO - Leak during heat- up or initial operation.
LCU - Leak corresponding to thermal or pressure upset.
LTO - Leak after several months operation - piping.
LDS - Leak during shut down.



92

Sample Flange Joint Leak Report

1. Date: _____
2. Unit: _____
3. Equipment: _____
4. Joint Identification: _____
5. Iso or Drawing#: _____
6. Flange Size/ Press. Class: _____
7. Gasket Material / Type: _____
8. Flange Temp./ Bolt Temp: _____
9. Describe Leak Type: (wisp, drops, stream, emission)
10. Leak Timing (@hydro, @1st startup, @later startups,@cool down, @___ months operation, Other: _____
11. Bolt Lubricant Condition: _____
12. Describe the use of the joint. i.e. channel cover _____
13. Circle the best descriptive location and orientation.

Top East West North East South Bottom West

Piping Joints: Vertical, Horizontal

Top West North East South Bottom

14. Mark the leak location.
15. Measure the gap between the flanges at 4 locations.
Measure 8 locations for flanges larger than 30"
Measure the flange offset at 4 locations
16. Measure the torque it takes to move the nuts.
Record applied torque during tightening
17. Mark nuts with the following marks after applying torque:

Nuts do not turn = 0	Nuts turn slightly = X
Nuts turn = XX	Nuts turn very easily = XXX

18. Leakage status: No Change __Reduced __ Stopped __
19. Adverse conditions: _____
20. Comments: _____
21. Recommendations: _____
22. Names: _____
23. Signatures: _____

(LTO) Leak after long term (months) of operation

Tell-Tale Signs	**Possible Cause**	Potential Solutions
Gasket structure/filler missing or no longer flexible or compliant	Gasket Chemical Degradation (chemical decomposition, o~~O~~xidation, etc.)	Change gasket type
Spring hangers incorrect, support lift-off, incorrectly placed restraints	Improper ~~Pipe~~ pipe support or restraint	See same item in LIO
Bolts are not tight on inspection	Bolt load loss due to long term gasket creep	See same item in LIO
Bolts not tight on inspection, Obvious ~~Gasket~~ gasket deterioration, gasket structure no longer sound	Physical gasket degradation, gasket unsuitable for operating temperature	Replace gasket with a type suitable for operating conditions
Gasket structure no longer sound (double jacket broken or windings buckled) Marks on gasket surface corresponding to radial flange face movement	Gasket Physical Degradation due to flange differential radial movement	• Remove all flange face nubbins • Replace gasket with one capable of radial shear and taking greater abrasion(spiral wound, kammprofile or corrugated)

Publication Status

PCC-1-2000 Update:

- Post Construction Standards Committee (PCSC) approval Of Updated PCC-1 (minus Appendix A)
- Appendix A recirculation ballot submitted to PCSC
  - Ballot closes July 28, 2009 (minor editorial comments rcvd)
  - 2nd recirculation ballot closes August 18, 2009
- Submit complete PCC-1 Update, including Appendix A, for review by Board of Pressure Technology Codes and Standards (BPTCS) ~August 19, 2009
- Submit to Codes & Standards Publishing ~August 19, 2009
- Publication expected late 2009