Subject Matter Study Report

**Excessive Regulatory Exemptions on Low Hoop Stress Piping**

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**Excessive Regulatory Exemptions on Low Hoop Stress Piping**

**Executive Summary**

DOT regulations and pipeline codes exempt certain pipelines and certain pipeline requirements because of a perception that certain piping presents little or no risk to public safety or the environment. The exemptions are based on:

1. Location of the pipeline,
2. Size of the pipeline,
3. Fluids transported, and
4. Operating hoop stress due to internal pressure, and
5. Gathering versus transmission classification.

The apparent rationales of government regulatory agencies for these exemptions are:

1. Pipelines remote from people’s houses, businesses, and places of work will not kill people.
2. Smaller pipelines will release a lower rate of hazardous fluid and cause smaller fires.
3. Because of their size, smaller pipelines are often operated at a lower stress level.
4. Natural gas pipelines are unlikely to significantly affect the environment.
5. Pipeline leaks are not hazardous unless you can see or hear the leak.
6. Lower hoop stress piping is unlikely to rupture and usually only leaks.
7. Environmental issues are not important.
8. Gathering lines are located in rural areas.
9. Only issue regulations supported and agreed to by the pipeline industry.
10. Minimize cost of pipeline compliance.

Whenever stress is covered in a pipeline regulation or piping code, the reference is usually to nominal hoop stress from internal pressure. Areas of corrosion, dents, and other geometric changes have higher stresses, but these higher stresses are not considered in formulating compliance analysis and requirements.

Numerous studies in the past sponsored by the pipeline industry consistently show that hoop stress is not a consistent indicator of pipeline safety problems.

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**Introduction**

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**DOT Requirements Related to Hoop Stress**

Whenever stress is covered in a pipeline regulation or piping code, the reference is usually to nominal hoop stress from internal pressure. Areas of corrosion, dents, and other geometric changes have higher stresses, but these higher stresses are not normally considered in formulating compliance requirements.

*49 CFR Part 192*

Title 49 CFR Part 192 contains the following requirements and exemptions due to hoop stress or internal pressure:

1. Onshore gathering lines that operate at less than 0 psig are exempt from all regulation [192.1(a)(4)].
2. A type A metallic regulated gas gathering pipeline operates with a MAOP of 20% or more of SMYS in a Class 2, 3 or 4 location.
3. A type A nonmetallic regulated gas gathering pipeline operates with a MAOP above 125 psig in a Class 2, 3 or 4 location.
4. A type A regulated gas gathering pipeline is subject to all the rules of a transmission line other than the integrity management and instrumented pig passage requirements [192.150].
5. A type B regulated gas gathering line is a pipeline with hoop stress or pressure lower than a type A regulated gas gathering line in a modified Class 2 or a Class 3 or 4 location.
6. A new, replaced, relocated, or otherwise changed type B regulated gas gathering line must comply with the design, installation, construction, initial inspection, and initial testing requirements applicable to a transmission line.
7. A type B metallic regulated gas gathering line must comply with the corrosion control requirements [Subpart I].
8. All type B regulated gas gathering lines shall comply with:
9. 192.614 on damage prevention program,
10. 192.616 on public education,
11. 192.619 on MAOP, and
12. 192.707 on line markers.
13. A gas gathering pipeline in a Class 1 area is not subject to DOT regulation.
14. A pipeline operated at a hoop stress of 20% or more of SMYS with a diameter to wall ratio of 70 to 1 or more, must comply with API 5L1 if the pipe is railroad transported.
15. For pipe transported before November 12, 1970, the pipe must be pressure tested to at least 1.25 times the MAOP in Class 1 locations and at least 1.5 times the MAOP in Class 2, 3 or 4 locations at a duration of at least eight hours.
16. Orange-peel bull plugs and swages may not be used on piping operated at a hoop stress of 20% or more SMYS.
17. Each support on an exposed pipeline operated at a stress level of 50% or more of SMYS must:
18. Not be welded to the pipe and
19. Must completely encircle the pipe.
20. A welder on pipe to be operated at a hoop stress of 20% SMYS or more must be qualified in accordance with API 1104.
21. A welder may qualify to the lesser requirements in Appendix C of CFR Part 192 to perform welding on pipe to be operated at a hoop stress of less than 20% SMYS (see Appendix C).
22. A miter joint greater than three degrees (3°) may not be used in piping operated at a hoop stress of 30% or more SMYS.
23. A miter joint greater than 12.5 degrees (12.5°) may not be used on piping operated at a hoop stress more than 10% SMYS.
24. A miter joint greater than 90 degrees (90°) may not be used on piping operated at a hoop stress of 10% or less SMYS.
25. Welds in piping to be operated at a hoop stress of 20% or more SMYS must be NDT. However, on pipe 6-inch or less in diameter to be operated at a hoop stress of less than 40% SMYS, the welds do not require NDT if the number of welds is low and weld inspection is performed by a qualified inspector.
26. The following dents that operate at a hoop stress of 20% SMYS or more must be repaired:
27. Contain a stress concentrator such as a scratch, gouge, groove, or arc burn or
28. Affect a longitudinal or circumferential weld.
29. The following dents must be repaired that operate at a hoop stress of 40% SMYS or more and contain a depth of:
30. More than 1/4-inch in 12-inch or smaller pipe or
31. More than 2% of diameter in pipe over 12-inch.
32. Arc burns in pipe operated at a hoop stress of 40% SMYS or more must be repaired.
33. Wrinkle bends are not permitted if the hoop stress is 30% SMYS or more.
34. Each transmission line to be operated at hoop stress of 20% or more SMYS must be installed to minimize stresses and to protect the pipe coating.
35. Each segment of pipe to be operated at a hoop stress of 30% or more SMYS must be strength tested in accordance with Subpart J.
36. During a pressure test, whenever the test pressure exceeds 50% SMYS, all practical steps shall be taken to keep persons not working on the test to be outside the test area.
37. A pipeline to have an uprating in MAOP must comply with 192.555 if the uprated hoop stress is 30% or more SMYS.
38. An operator must take immediate temporary measures to protect the public whenever a leak, imperfection or damage that impairs its serviceability is found in a segment operating at 40% or more SMYS.
39. Each imperfection or damage that impairs the serviceability of pipe in a line operating at 40% or more SMYS must be replaced or repaired.
40. Repair leaks with a full encirclement welded split sleeve unless the pipeline operates at less than 40% SMYS.
41. Maximum integrity management reassessment intervals are:
42. Hoop stress of 50% or more SMYS = 10 years,
43. Hoop stress > 30% SMYS to < 50% SMYS = 15 years, and
44. Hoop stress < 30% SMYS = 20 years.

*49 CFR Part 195*

Title 49 CFR Part 195 contains the following requirements and exemptions due to hoop stress and internal pressure.

1. Low-stress pipeline operates in its entirety at a stress level of 20% or less SMYS.
2. Onshore low stress pipelines in rural areas and outside commercial navigation areas that do not transport HVL’s are exempt from DOT regulation.
3. Onshore low stress pipelines less than one mile long that serve refining, manufacturing, truck, rail, or vessel terminal facilities and do not cross an offshore or commercial navigation area are also exempt from DOT regulation.
4. Supports or braces may not be welded directly to pipe that will operate at a pressure of more than 100 psi.
5. Liquid petroleum that does not vaporize rapidly can be used for pressure testing onshore pipelines if each building within 300 feet of the test section is unoccupied while the test pressure is equal to or greater than a hoop stress 50% SMYS.
6. Risk factors for establishing frequency of integrity assessment include “operating stress levels in the pipeline” [see Appendix C, II.A.(15)].

*ASME B31.8*

ASME B31.8 contains the following requirements and exemptions due to hoop stress and internal pressure.

1. For piping to be operated at hoop stress of 20% or more SMYS, welders and welding procedures shall be qualified under API 1104 or ASME IX.
2. For piping to be operated at a hoop stress of 20% or more SMYS, each weld shall be visually inspected and receive supplemental NDT of 10% to 100% of the welds.
3. For piping to be operated at a hoop stress of 20% or more SMYS, defective welds shall be repaired.
4. Branch connections shall meet the requirements of Table 831.42 for hoop stress ranges of:
5. 20% or less SMYS,
6. More than 20% through 50% SMYS, and
7. More than 50% SMYS.
8. Maximum stress in closure heads is 60% SMYS.
9. Orange-peel bull plugs and swages are not permitted on piping operated at 20% or more SMYS.
10. If piping is designed to operate at a hoop stress of less than 50% SMYS, supports may be welded to the pipe.
11. When a pipeline operates at a hoop stress over 40% SMYS in sizes NPS 16 and larger, a fracture control criteria shall be specified.
12. When a pipeline operates at a hoop stress over 72% SMYS in sizes smaller than NPS 16, a fracture control criteria shall be specified.
13. Maximum hoop stress design factors to apply against SMYS are given in Table 841.114B.
14. Installation inspection requirements for piping to operate at 20% or more SMYS are given in Section 841.222.
15. Wrinkly bends are permitted in piping systems that operate at less than 30% SMYS.
16. For piping systems operated at 40% or more SMYS, miter deflections are limited to three degrees (3°).
17. For piping systems operated at 10% or more SMYS, miter limited to 12.5 degrees (12.5°).
18. For piping systems operated at less than 10% SMYS, the total miter deflection shall not exceed 90%.
19. For piping systems operated at 10% or more SMYS, the minimum distance between miters measured at the crotch shall not be less than one pipe diameter.
20. Pipe surface defect limits in Section 841.24 apply to piping operated at 20% or more SMYS.
21. All dents that exceed a depth of ¼-inch in NPS 12 and smaller or 2% of the diameter in pipe sizes greater than NPS 12 in piping operated at 40% or more of SMYS shall be removed.
22. Metallurgical notches (such as arc burns) shall be prevented or eliminated in all piping operated at 20% or more SMYS.
23. For piping systems operated at 20% or more SMYS, stresses imposed during construction shall be minimized.
24. Piping systems operated at 30% or more SMYS shall be pressure tested to prove strength for at least two (2) hours.
25. Pressure testing factors applied to MAOP vary from 1.25 to 1.4 depending on piping location.
26. Uprating procedures apply to piping to be uprated to 30% or more SMYS.
27. Piping repair requirements apply to piping operated at or above 30% SMYS.

*ASME B31.4*

ASME B31.4 contains the following requirements and exemptions due to hoop stress and internal pressure.

1. B31.4 does not apply to piping designed for internal pressure at or below 15 psig.
2. Branch connections shall meet the requirements of Table 404.3.1(c) for hoop stress ranges of:
3. 20% or less SMYS,
4. More than 20% through 50% SMYS, and
5. More than 50% SMYS.
6. Miter bends are prohibited in pipelines intended to operate at a hoop stress more than 20% SMYS.
7. Miter bends not exceeding 12.5 degree may be used on pipelines intended to operate at a hoop stress of 20% or less SMYS.
8. Miter bends of any angle may be used on pipelines intended to operate at a hoop stress of less than 10% SMYS.
9. Orange peel swages are prohibited in pipelines operating at hoop stresses more than 20% SMYS.
10. If pipe is designed to operate above 20% SMYS, all attachments welded to the pipe shall be made to a separate cylindrical member that completely circles the pipe and this encircling member shall be welded to the pipe by continuous welds.
11. Weld-on patching, other than full encirclement, is not permitted during construction of pipelines intended to operate at a hoop stress of more than 20% SMYS.
12. Insert patching, overlay, or pounding out of dents shall not be permitted during construction of pipelines intended to operate at a hoop stress of more than 20% SMYS.
13. During pipeline construction, all dents that exceed a maximum depth of ¼ inch in NPS 4 and smaller pipe or 6% of the nominal pipe diameter in sizes greater than NPS 4 shall not be permitted in pipelines intended to operate at a hoop stress greater than 20% SMYS.
14. When the pipeline is to be operated at a hoop stress of more than 20% SMYS, at least 10% of the girth welds shall be tested by radiographic or other volumetric NDT method.
15. Pipelines to be operated at a hoop stress of more than 20% SMYS shall be hydrostatically tested to at least 1.25 times the internal design pressure.
16. When pressure tests are above 90% SMYS, “special care shall be used to prevent overstrain to the pipe”.
17. A one hour hydrostatic or pneumatic leak test may be used for pipelines to be operated at a hoop stress of 20% or less of SMYS.
18. For pipelines to be operated at a hoop stress of 20% or more SMYS, replacement pipe sections shall be pressure tested as required for a new pipeline before or after installation of the replacement pipe. The replacement pipe can be pressure tested before installation if installation welds receive radiographic or other acceptable NDT methods.
19. For pipelines to be operated at a hoop stress of 20% or more SMYS, repair welds shall be visually inspected by a qualified inspector and at least one other NDT method.
20. If a pipeline is uprated to a hoop stress of more than 20% SMYS, the uprating procedure in section 456 shall be followed.

**Analysis of Reported Gas Pipeline Incident Data**

Five reports that contain data on incidents of gas pipeline ruptures are:

1. Unnumbered AGA report by Gideon, Kiefner and Smith of Battelle on gas transmission and gathering pipeline incidents during 1970-1973;
2. AGA Report No. 158 on gas transmission and gathering pipeline incidents during 1970 through June 1984;
3. AGA Report No. 200 on gas transmission and gathering pipelines, June 1984 through 1990;
4. AGA Report No. 213 on gas transmission and gathering pipeline, June 1984 through 1992; and
5. PRC Report PR-218-9406 on gas transmission and gathering pipeline incidents during January 1, 1985 through December 31, 1994 (see Table 1).

*Unnumbered AGA Report*

Relevant information on the effects of stress level on reported to DOT pipeline incidents was:

1. During 1970-1973 (four years), about 36% of the ruptures due to outside forces occurred at a hoop stress of less than 3 ksi. About 50% of the ruptures due to outside forces occurred at a hoop stress of 4-5 ksi or less. About 80% of the ruptures due to outside forces occurred at a hoop stress of 12-15 ksi or less.
2. During 1970-1973, about 10% of the ruptures due to corrosion and about 8% of the ruptures due to construction or material defect occurred at a hoop stress of 1ess than 3 ksi. About 50% of the ruptures due to corrosion occurred at a hoop stress of 9-12 ksi or less.
3. During 1970-1973, about 50% of the ruptures due to construction or material defect occurred at a hoop stress of 12-15 ksi or less.
4. During 1970-1973, about 40% of the leaks due to outside forces occurred at a hoop stress of 1ess than 3 ksi. About 50% of the leaks due to outside forces occurred at a hoop stress of 3-6 ksi or less. About 80% of the leaks due to outside forces occurred at a hoop stress of 9-12 ksi or less.
5. During 1970-1973, about 18% of the leaks due to corrosion occurred at a hoop stress of 1ess than 3 ksi. About 50% of the leaks due to corrosion occurred at a hoop stress of 4-7 ksi or less. About 80% of the leaks due to corrosion occurred at a hoop stress of 9-12 ksi or less.
6. During 1970-1973, about 15% of the leaks due to construction or material defect occurred at a hoop stress of less than 3 ksi. About 50% of the leaks due to construction and material defects occurred at a hoop stress of 18-21 ksi or less. About 80% of the leaks due to construction and material defects occurred at a hoop stress of 27-30 ksi or less.
7. During 1970-1973, 1635 incidents were reported. Incident causes were:
8. Corrosion – 247 (15.1%),
9. Outside forces – 886 (54.2%),
10. Material failure – 299 (18.3%),
11. Construction defect – 86 (5.2%),
12. Other – 117 (7.2%), and
13. Total 1635 (100%).
14. Fifteen (15) out of 1635 incidents were reported at occurring above the MAOP for the failed piping.
15. Over 70% of all incidents occurred at stress levels below 40% SMYS for Grade B pipe.
16. On the effects of failure stress level, this report contained the following statements:
17. Without the knowledge of the mileage operated at the various stress levels, it is not possible to evaluate completely the effect of stress upon the frequency of incidents.
18. Nevertheless, these data suggest that the number of incidents that occurred would not have been appreciably diminished if the allowable stress levels had been lowered.
19. The above comments are not consistent with the reported incident data. A primary cost and profit issue for pipeline companies is the allowable stress level and wall thickness of the line pipe. Pipeline companies have aggressively supported current stress limits and have recently obtained an increase in operating stress level to 80% SMYS for remote areas.
20. The estimated percent of incidents versus stress level for ruptures from figure 9 in the subject unnumbered AGA report were:

Percent of Incidents – Ruptures

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hoop Stress ksi | Corrosion | Outside Forces | Const. Defect/Matl. Failure | Total |
| 1-3 | 10 | 36 | 8 | 18.0 |
| 3-6 | 10 | 5 | 12 | 9.0 |
| 6-9 | 10 | 14 | 10 | 11.3 |
| 9-12 | 20 | 19 | 3 | 14.0 |
| 12-15 | 5 | 8 | 13 | 8.7 |
| 15-18 | 5 | 3 | 10 | 6.0 |
| 18-21 | 4 | 3 | 5 | 4.0 |
| 21-24 | 8 | 2 | 4 | 4.7 |
| 24-27 | 9 | 3 | 6 | 6.0 |
| 27-30 | 1 | 3 | 6 | 3.1 |
| 30-33 | 2 | 1 | 6 | 3.0 |
| 33-36 | 5 | 1 | 13 | 6.3 |
| 36-39 | 5 | 1 | 1 | 2.3 |
| 39+ | 7 | 1 | 4 | 4.0 |
| Totals | 100 | 100 | 100 | 100 |

1. The percent of incidents versus stress level for leaks from figure 8 in the subject unnumbered AGA report were:

Percent of Incidents – Leaks

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Hoop Stress ksi | Corrosion | Outside Forces | Const. Defect/Matl. Failure | Total |
| 1-3 | 18 | 40 | 15 | 24.3 |
| 3-6 | 24 | 8 | 10 | 14.0 |
| 6-9 | 30 | 14 | 4 | 16.0 |
| 9-12 | 10 | 20 | 10 | 16.7 |
| 12-15 | 3 | 2 | 9 | 4.7 |
| 15-18 | 2 | 4 | 2 | 2.7 |
| 18-21 | 2 | 3 | 2 | 2.3 |
| 21-24 | 2 | 2 | 4 | 2.7 |
| 24-27 | 2 | 2 | 8 | 4.0 |
| 27-30 | 2 | 1 | 11 | 4.7 |
| 30-33 | 1 | 1 | 10 | 4.0 |
| 33-36 | 1 | 1 | 6 | 2.7 |
| 36-39 | 1 | 1 | 4 | 2.0 |
| 39+ | 2 | 1 | 3 | 2.0 |
| Totals | 100 | 100 | 100 | 100 |

1. The above tables clearly indicate that about half of the gas pipeline incidents occurred at low to moderate stress levels and the current codes and regulations should have eliminated or at least modified their exemptions of pipeline requirements based on stress levels.
2. The number of incidents versus stress level is not consistent with logic, because one would expect hoop stress level to have a dominating effect on increasing pipeline incidents.
3. The rupture data supports one or more of the following conclusions:
4. Gas pipeline companies place considerably more attention to incident prevention of highly hoop stressed pipelines than low to moderately hoop stressed pipelines.
5. Conversely, gas pipeline companies place considerably less attention to incident prevention of low to moderately hoop stressed pipelines.
6. The origins of gas releases that caused incidents and test failures were:

Percent of Incidents or Test Failures

|  |  |  |  |
| --- | --- | --- | --- |
| Origin of Release | All Incidents | Outside Force Incidents | Test Failures |
| Pipe body | 54.2 | 64.7 | 30.4 |
| Girth weld | 6.2 | 2.4 | 6.9 |
| Pipe seam weld | 5.8 | 0.2 | 57.9 |
| Tap connection | 5.1 | 8.6 | 0.2 |
| Fitting | 13.7 | 13.4 | 2.3 |
| All others | 14.9 | 10.7 | 2.2 |

1. Some of and perhaps many of the incidents involving fittings were likely at tap locations on gas pipelines. The data indicate that tap connections on gas pipelines are not adequately marked and protected; therefore, inspection and construction oversight near pipeline connections need to be improved.
2. The number of pipe weld failures during pressure tests versus incidents validated the value of pressure testing in removing defective pipe longitudinal weld seams.

*AGA Report No. 158*

Relevant information on the effects of stress level on pipeline incidents and pressure test failures was:

1. 5872 in-service incidents were reported over about 14.5 years.
2. 2013 pressure testing incidents were reported over about 14.5 years.
3. 5610 in-service incidents reported contained enough information to determine if a leak or rupture was involved with the incidents.
4. 35.7% (2003) of the incidents were indicated as ruptures.
5. 9.2% (514) of the incidents were indicated as ruptures that propagated more than one foot along the pipe axis.
6. Five previous analysis of DOT gas pipeline incident data between 1970 through 1978 indicated that about one third of all reportable incidents were classified as ruptures.
7. The number of incidents involved with exceeding the MAOP of the piping was 4.4%. In 1982, about 28% of the reported incidents involved exceeding the MAOP of the piping.
8. During 1970-1984, 14.8% (867) of the 5861 total number of incident reports did not include information on the failure pressure of the piping. The DOT failed to require complete data in these and other incident reports.
9. The percentages of reported incidents versus stress level at failure were:

|  |  |
| --- | --- |
| Stress Level, ksi | Percent of Incidents |
| 0-3 | 22.2 |
| 3-6 | 16.8 |
| 6-9 | 13.3 |
| 9-12 | 8.0 |
| 12-15 | 6.3 |
| 15-18 | 3.4 |
| 18-21 | 2.6 |
| 21-24 | 2.9 |
| 24-27 | 2.0 |
| 27-30 | 1.7 |
| 30-33 | 1.6 |
| 33-36 | 1.4 |
| 36-39 | 0.7 |
| 39+ | 2.4 |
| N.A.\* | 14.8 |

\*Not available

1. Fifty-two and three tenths percent (52.3%) of all incidents occurred at a hoop stress of 9 ksi or less. For incidents with reported failure stress data, 61.4% (52.5% ÷ 0.852) of the incidents occurred at a hoop stress of 9 ksi or less (17.3% or less SMYS in X-52 pipe).
2. The data on reported incidents versus failure stress level clearly show that stress level by itself is a poor criterion for allowing exemptions on pipeline safety requirements.
3. The percentages of reported pressure testing failures versus failure stress level for 1970 through 1982 were:

|  |  |
| --- | --- |
| Stress Level, ksi | Percent of Incidents |
| 0-3 | 2.0 |
| 3-6 | 2.6 |
| 6-9 | 1.9 |
| 9-12 | 2.7 |
| 12-15 | 3.0 |
| 15-18 | 2.7 |
| 18-21 | 5.1 |
| 21-24 | 3.9 |
| 24-27 | 3.4 |
| 27-30 | 3.8 |
| 30-33 | 7.5 |
| 33-36 | 5.1 |
| 36-39 | 6.3 |
| 39+ | 47.5 |
| N.A.\* | 2.7 |

\*Not available

1. Test incidents versus stress level should have been reported for increments of stress level above 39 ksi to more clearly show the effects of test stress level.
2. The pressure testing failure versus stress level shows the benefits of pressure testing at higher stress levels than lower stress levels.
3. During 1970-1984, 62.5% of the reported in service incidents occurred in the body or longitudinal weld of line pipe. Six percent (6%) of the incidents occurred in girth welds. Fifteen and six tenths percent (15.6%) of the incidents occurred in tap connections and fittings. Scraper traps were only associated with 0.1% of the incidents. Two and seven tenths percent (2.7%) of the incidents were associated with valves.
4. The DOT incident report categories on “part of system which leaked or failed” and “origin of leak or failure” were inadequate to describe the types of facilities associated with incidents.
5. This report also included an inappropriate comparison of transportation fatalities with other modes of transportation including:
6. Passenger cars,
7. Large trucks,
8. Pedal cycles,
9. Motorcycles,
10. Pickup trucks and vans,
11. Pedestrians,
12. Railroad,
13. Airlines,
14. General aviation,
15. Marine, and
16. Recreational.
17. The comparison should have only included bystanders killed by freight transportation means to be more realistic. Pipelines do not transport people.
18. In 1983, there were 46,115 transportation related deaths. Sixteen were due to pipeline incidents. Some later comparisons of pipeline caused fatalities only covered freight transportation.
19. The report was heavily biased in trying to show the positive side of gas pipeline transportation of which there were many. However, the pipeline industry showed no evidence of attempting to expand the data bases on pipelines to provide more cause and effect data needed for objective risk analysis and for evaluation of codes and regulations.

*AGA Report No. 200*

Relevant information on the effects of stress level on pipeline incidents included:

1. In July 1984, the DOT changed the incident definition to reduce the number of reported incidents. Incident reporting criteria was changed as follows:
2. The estimated property damage was to include the cost of lost gas and the amount of damage was increased from $5,000 or more to $50,000 or more.
3. Gas ignition reporting criteria was deleted.
4. Leaks requiring immediate repair were deleted from the incident reporting criteria.
5. Injuries requiring hospitalization were changed to injuries requiring in-patient hospitalization to eliminate injuries that received only hospital emergency treatment.
6. Pressure testing failures were deleted.
7. In July 1984, the amount of data required in incident reports was reduced.
8. Over the 6.5 year period, 536 onshore incidents and 85 offshore incidents were reported to the DOT.
9. Onshore incidents caused 118 injuries and 26 fatalities.
10. Offshore incidents caused 6 injuries and 18 fatalities.
11. During this period, gas pipelines received $42.5 billion in transportation revenue.
12. The percent of onshore gas pipeline incidents versus failure stress level were:

|  |  |
| --- | --- |
| Hoop Stress, % SMYS | Percent of Total |
| ­< 10% | 34.7 |
| > 10% to < 20% | 9.3 |
| > 20% to < 30% | 12.3 |
| > 30% to < 40% | 14.4 |
| > 40% to < 50% | 8.6 |
| > 50% to < 60% | 5.6 |
| > 60% to < 70% | 6.9 |
| > 70% to < 80% | 6.0 |
| > 80% to < 90% | 0.9 |
| > 90% to < 100% | 1.3 |

1. The percent of offshore gas pipeline incidents versus failure stress level were:

|  |  |
| --- | --- |
| Hoop Stress, % SMYS | Percent of Total |
| ­< 10% | 22.4 |
| > 10% to < 20% | 3.5 |
| > 20% to < 30% | 21.2 |
| > 30% to < 40% | 8.2 |
| > 40% to < 50% | 28.2 |
| > 50% to < 60% | 15.3 |
| > 60% to < 70% | 0 |
| > 70% to < 80% | 1.2 |
| > 80% to < 90% | 0 |
| > 90% to < 100% | 0 |

*AGA Report No. 213*

Relevant information on the effects of stress level on pipeline incidents reported for June 1984 through 1992 included:

1. Report was published July 1995.
2. Report covered eight and one-half (8.5) years of incidents.
3. Six hundred eighty-five (685) onshore incidents were reported.
4. One hundred ten (110) offshore incidents were reported.
5. These incidents caused 164 injuries and 47 fatalities.
6. Two hundred ten (210) onshore incidents resulted from ruptures and 249 resulted from leaks. Two hundred twenty-six (226) incidents could not be determined as leaks or ruptures because of inadequate report completion.
7. No analysis on the effects of stress level was included in the report.
8. For 629 incidents with enough information to make an analysis, 20 incidents (3.2%) occurred above the MAOP of the pipeline.

*AGA Report No. 218*

Relevant information on the effects of stress level on pipeline incidents reported for January 1, 1985 through December 31, 1994 is summarized in Table 1. The data in Table 1 are summarized as follows:

1. Report was dated May 31, 1996.
2. The effect of stress level was not covered in this report as was the case in numerous previous reports on analysis of gas pipeline incidents.
3. Eight hundred sixty-five (865) incidents were reported during this ten year period.
4. One hundred eighty-two (182) or 21% of the reported incidents were at compressor, meter, and pressure control stations.
5. Six hundred eighty-three (683) or 79% of the reported incidents involved piping or pipeline facilities between stations.
6. The causes of incidents were broken down in more categories than reported by the DOT.
7. The PRC report attempted to classify external force incidents as ruptures, punctures, tears, leak, or none although the DOT incident reports only covered rupture, leak, and other to describe the pipeline release condition.
8. This report included the individual data on each of the 865 incidents.
9. Enclosed is Table 1 that contains data on the incidents that reported a rupture length although PRC Report No. 218 attempted to classify some of the incidents as non-ruptures.
10. For example, the report classified incident No. 900214 as a 30-foot long tear. Incident No. 890065 was classified as a 6-foot long puncture. These incidents were probably ruptures due to their length.

**Analysis of Reported Petroleum Pipeline Incident Data**

Two reports that contain data on incidents of liquid petroleum pipelines are:

1. API Research Study #040 on a sample of incidents that occurred during 1968 through 1986.
2. API Publication 1158 on reported incidents that occurred during 1986 through 1996.

*API Research Study #040*

Relevant information in API Research Study #040 included:

1. Study was performed to examine the cost/benefit of several pipeline safety issues.
2. Study included only interstate hazardous liquid pipelines.
3. Questionnaire was completed by 99 companies on 206 pipeline systems covering 113,345 miles of onshore interstate pipelines.
4. Ten companies did not respond to the questionnaire.
5. It was believed that there were about 220,000 miles of hazardous liquid pipelines in the USA with about half being interstate and about half being intrastate.
6. On the sample average, pipelines were operating at 70% of capacity.
7. For 1968 through 1986, 4948 incidents were reported to the US DOT. Of these, 4118 occurred in piping segments and 830 occurred in pump stations, terminals, and tanks.
8. Three hundred twenty-nine (329) of the incidents were indicated as serious by causing 72 deaths, 184 injuries, and $30.63 M ($93,000 per incident) in property damage.
9. The study used a value of $2,000,000 on each life and $500,000 on each personal injury.
10. The report calculated the annual cost of hazardous pipeline incidents to be $18.86 M due to deaths, injuries, property damage, and lost transported liquids. No environmental costs were included. Litigation costs were not included.
11. Incident damage was divided by cause as:
12. Corrosion and defective pipe,
13. Third party,
14. Incorrect operation, and
15. Other.
16. The “other” category caused the most deaths of the four cause categories.
17. Table 10 in the report was a comparison of incident damage potential of pipelines versus railroads, motor carriers, and water carriers.
18. Table 10 did not include the effects of all the deaths, injuries, and property damage caused by pipelines.
19. Table 10 also lumped together the effects of railroads, motor carriers, and water carriers together. The data clearly shows that water carriers are safer than pipelines and motor carriers are less safe than other modes of transportation.
20. Intrastate pipeline deaths, injuries, and property damage were not excluded from Table 10.
21. This report contained no information on the effects of operating pressure or hoop stress on pipeline incidents.

*API Publication 1158*

Relevant information in API 1158 on the effects of hoop stress level is:

1. One thousand three hundred sixty-eight (1368) piping related incidents were reported and 894 non-piping incidents were reported.
2. Four hundred twenty-four (424) of the 1368 piping related incidents were not completed to indicate hoop stress data.
3. For the 944 incidents reports with hoop stress failure data, the effects of stress level were:

Number of Incidents

|  |  |  |
| --- | --- | --- |
| Stress Level  % SMYS | Number | % of Total |
| 0 to 9.9 | 277 | 29.3 |
| 10 to 19.9 | 171 | 18.1 |
| 20 to 29.9 | 148 | 15.7 |
| 30 to 39.9 | 127 | 13.5 |
| 40 to 49.9 | 88 | 9.3 |
| 50 to 59.9 | 65 | 6.9 |
| 60 to 69.9 | 47 | 5.0 |
| 70 to 79.9 | 14 | 1.5 |
| 80 to 89.9 | 4 | 0.4 |
| 90 to 99.9 | 3 | 0.3 |

1. Forty-seven and four tenths percent (47.4%) of piping incidents occurred at 19.9% SMYS or less.

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