Vintage Plastic Common Failures & Mitigative Measures

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Agenda

- Early Plastic Industry Timeline and Background
- Various Vintage Plastic Pipes & Fittings
- Review of PHMSA Advisory Bulletins:
  - Premature (Brittle-Like) Cracking
  - Delrin Inserts
  - Plexco Celcon Caps
- NTSB 1998 Investigative Report
- Plastic Pipeline Data Committee (PPDC) Failure Data
- Mitigative Measures

1958-1969 Plastic Timeline

1958 — In November 1958, the Thermoplastic Pipe Division of the Society of the Plastics Industry organized a group called the Working Stress Subcommittee

1963 — Plastics Pipe Institute issues procedure specifying uniform protocols for rating material strength in the manufacturing of thermoplastic pipe.

1965 — DuPont Pipe started manufacturing Aldyl A with the resin Alathon 5040

1966 — First standard specification covering PE plastic piping for gas service (ASTM D2513)

1967 — Plastic Pipe included into B31.8 codes (Gas Transmission and Distribution Piping Systems).

1968 — Natural Gas Pipeline Safety Act was enacted, requiring the DOT to adopt minimum Federal regulations for gas pipelines.

Background

- DuPont and Phillips Petroleum were two of the early main developers of PE pipe. Phillips developed butt fusion in 1955, and shortly thereafter installed pipes in oil field gathering applications. It was about this same time that engineers developed the extrusion process, which made PE pipe economical to manufacture.
- Mid-1960s, utilities began transition to plastic from cast iron and steel pipe. DuPont and Phillips Petroleum were two early developers of plastic pipe.
- The early Aldyl A, manufactured by DuPont, is known to exhibit brittle-like failures. This was in part due to the resin and other stresses.
- In 1985, ASTM D2513 was revised to require materials for gas service have a PPI listing.

PPDC Historic Pipe Manufactuers

- "[To view the PPDC Manufacturing History Database click here.]"
- Good starting point for estimating various production runs of 1st generation plastic and beyond.
- Review this listing and raise awareness amongst field employees.

Manufacturers of Plastic Piping Products - Pipe

The following is a list of manufacturers of plastic pipe for gas distribution operations.
The list may be incomplete, but does list most of the primary companies involved in reports to the PPDC
NOTE: Operators are required to install materials that meet current requirements.

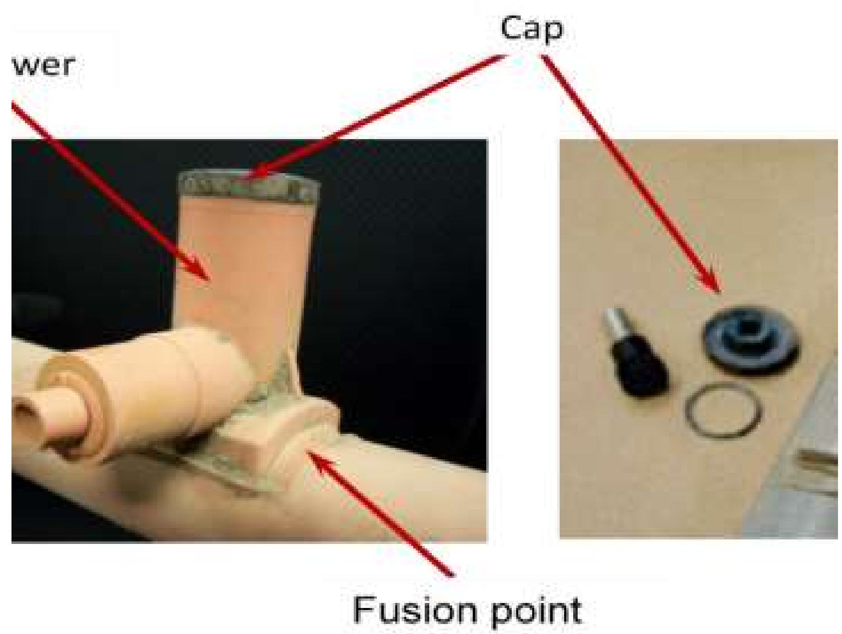
Company	Material Designation	From	To	Size Range	Comments
Allied	PE 3306/3406	1965/66	1972/73	1/2" CTS - 2" IPS	Was also a resin producer and supplied the AC ultra high molecular pipe compound to several small pipe extruders including Yardley, Orangeburg, Endot and the Barrett Division of Allied (also an extruder of PVC pipe). Except for Endot, most of these producers/extruders have since gone out of business or have different names today. Pipe was very difficult to fuse.
Amstan	PE3306	Mid-late 1960s			
Barrett	PE3306	Mid-late 1960s			Division of Allied
Black Plastic					
Cabot					
Celenese Pipe					Tubing manufacturer ultimately owned by Solvay
Century Pipe					Early 1970's (Tan)
	PE 2306	1970	1974	1/2" CTS - 4" IPS	

PHMSA Advisory Bulletin – Early Vintage PE Pipe

- PHMSA ADB-99-02 and ADB-02-07 Warning of premature cracking.
  - Plastic pipes installed between 1960 and early 1980s
    - Advisory further warns that rupture testing standards may have overrated the long-term resistance to brittle-like cracking
  - PHMSA Recommendation
    - Recommends operators to identify all pre-1982 plastic pipe installations, analyze leak histories, and evaluate any conditions that may impose high stresses on the pipe.
    - For systems with no record of the piping material, consider recording print line data when piping is excavated for other reasons.
    - Record print line information from failed pipes.
    - Use consistent format to collect data on system failures.

PHMSA Advisory Bulletin – Delrin Insert

- ADB-07-01 Delrin inserts in DuPont Service Tees susceptible to brittle-like cracking.
- AGA data further show that failures due to fittings account for almost 50% of all leaks on Aldyl A pipelines. Aldyl A fittings susceptible to failure include Delrin polyacetal inserts in DuPont service Tees, Aldyl A Tees, Aldyl A saddles, and Aldyl A couplings.



PHMSA Advisory Bulletin – Plexco Service Tee Celon Cap

- PHMSA released a notification in 2007 around older plastic pipe. This report also mentioned Plexco service tee Celcon caps. Caps not properly installed (overtightened with wrench) caused problems. Designed to be hand tightened.

Wrench marks on cap

Black cap on orange tee

Black cap can be on yellow tee as well

*Pre-1996 Plexco tapping tee caps contain the Celcon polyacetal

NTSB 1998 Special Report

- One highlighted incident occurred in 1994 in Iowa.
- 1/2” plastic service pipe failed in a brittle-like manner at the connection to steel main. This service pipe was manufactured in 1970 by Century/Amdevco.
- The investigation determined that much of the top portion of the circumference of the pipe immediately outside the tee’s internal stiffener displayed several brittle-like slow crack initiation and growth fracture sites

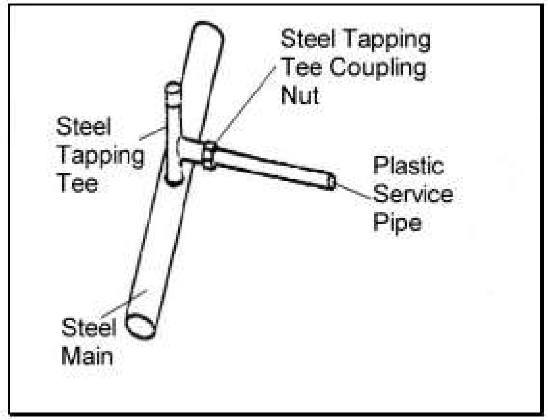
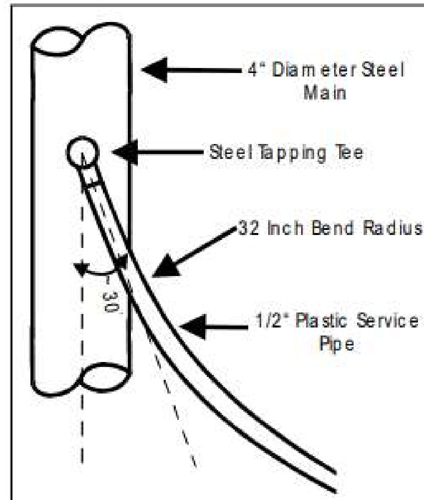


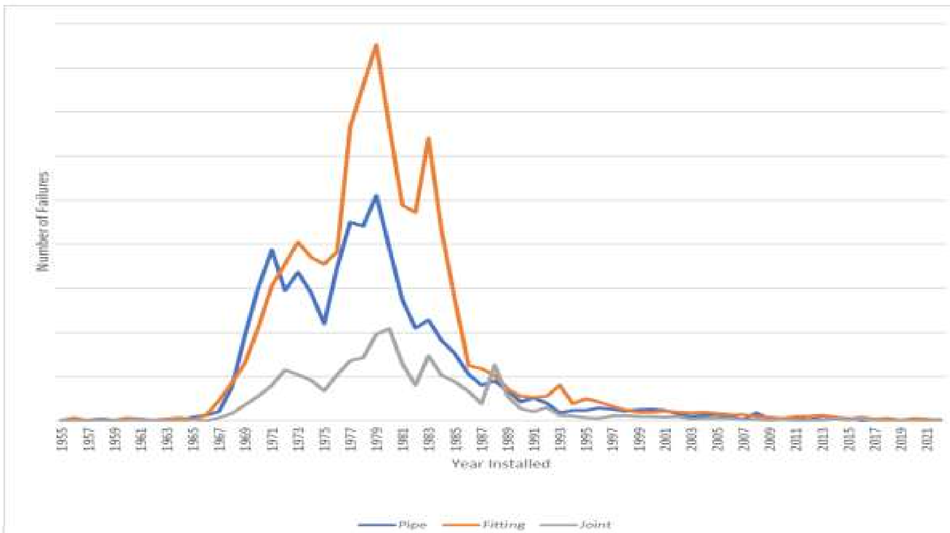
Figure 2 -- Typical plastic service pipe connection to steel gas main. Many connections are protected against shear and bending forces by a plastic sleeve that encloses the service pipe-to-tee connection on either side of the coupling nut.



Service-to-main connection at site of Waterloo accident.

Figure 2. Failures by Years in Service as reported to PPDC for Aldyl pipe, fittings and joints

Figure 3 shows the failures by Year Installed. Although Figure 1 shows three data peaks, the year of installation range appears consistent.



PPDC - Dupont Aldyl A Pipe, fittings and joints

Source: Plastic Piping Data Collection (PPDC) Initiative - Status Report Novem 2023 able 2 displays the percentages of failure causes for Aldyl including pipe, fittings and joints.

CAUSE	% of All Dupont & Uponor Failures	% of All Dupont & Uponor Pipe Failures	% of All Dupont & Uponor Fitting Failures	% of All Dupont & Uponor Jo Failures
Cap (Other)	2.7%	0.0%	4.8%	0
Corrosion	1.2%	1.1%	1.5%	0
Excessive Expansion/Contraction	1.4%	0.9%	1.2%	4
Excessive External Earth Loading	7.9%	15.1%	4.2%	5
Gopher/Rodent/Worm damage	0.1%	0.4%	0.0%	0
Installation Error	21.6%	11.9%	18.7%	65
Material Defect	15.2%	6.8%	22.1%	5
Other	15.0%	17.1%	16.3%	1
Point Loading	8.9%	22.2%	2.2%	3
Previous Impact	1.5%	4.2%	0.1%	0
Squeeze Off	2.6%	7.7%	0.0%	0
Threaded Cap (Cracked Cap)	5.8%	0.0%	10.3%	0
Threaded Cap (Loose, not cracked)	1.0%	0.0%	1.8%	0
Threaded Cap(Other, Describe)	0.0%	0.0%	0.0%	0
Threaded Cap (Seal/O-ring defect)	0.8%	0.0%	1.4%	0
Unknown	13.6%	11.2%	15.1%	12
Unknown – Abandoned	0.1%	0.3%	0.0%	0
Unknown – Not Excavated, Replaced	0.6%	1.1%	0.3%	0
Total	100.0%	100.0%	100.0%	100

Table 2. Failures by Cause as reported to PPDC for Aldyl pipe, fittings and joints
Note: Percentages less than 0.1% are not listed in the chart

PPDC - Dupont Aldyl A Pipe & Fittings

Source: Plastic Piping Data Collection (PPDC) Initiative - Status Report November 2023

Fitting Type	% of Aldyl Fitting Failures between 2000 and 2005	% of Aldyl Fitting Failures between 2010 and 2015	% of Aldyl Fitting Failures between 2016 and 2022
Cap	0.2%	59.3%	13.1%
Electrofusion	0.1%	0.5%	1.4%
Heat Fusion	23.7%	17.0%	18.1%
Mechanical Fitting (Bolted)	0.1%	0.0%	0.1%
Mechanical Fitting (Nut Follower)	0.0%	0.5%	0.4%
Mechanical Fitting (Other)	2.5%	3.5%	2.5%
Mechanical Fitting (Stab)	0.0%	0.2%	0.0%
Meter Riser	13.6%	4.9%	1.8%
Other	29.0%	1.6%	1.5%
Threaded Cap	0.0%	1.6%	54.7%
Transition	16.1%	1.7%	0.3%
Unknown	4.7%	9.5%	4.9%
Valve	10.0%	1.2%	1.1%
Total	100.0%	100.0%	100.0%

Table 1: Fitting Types by Year Range of Failure

PPDC : Aldyl A Cap Failure Trends

PPDC - Kerotest Fitting Failures

FITTING	% of All Kerotest Fitting Failures
Electrofusion	0.1%
Heat Fusion	0.3%
Mechanical Fitting (Other)	8.0%
Mechanical Fitting (Nut Follower)	3.2%
Meter Riser	2.9%
Other	0.2%
Threaded Cap	0.1%
Transition	0.1%
Valve (Plastic)	84.8%
Unknown	0.4%
Total	100.0%

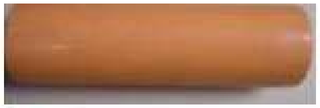
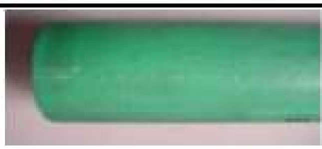
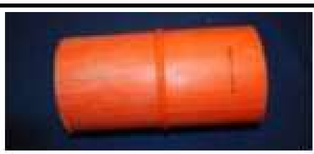
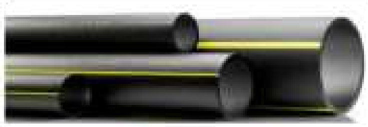
Table 1. Kerotest Fitting Failures by Type
Note: Percentages less than 0.1% are not listed in the chart

Source: Plastic Piping Data Collection (PPDC) Initiative - Status Report November 2023

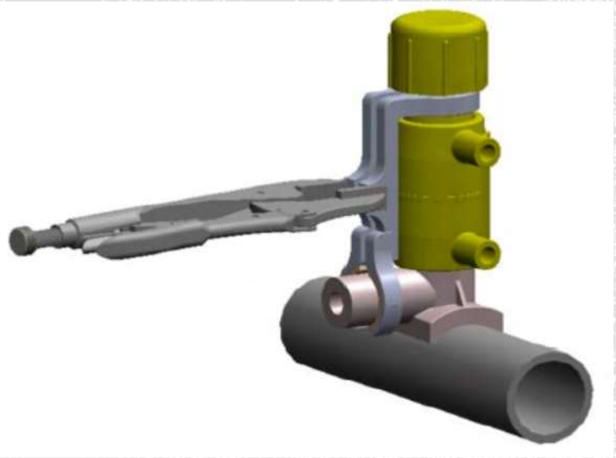
Potential Mitigative Measures

- Expanded replacement projects for ALDYL-A pipe where leaks and failures are discovered.
- Continued Surveillance: Collect unknown pipe and fitting material types through opportunistic field activities
  - Update records accordingly
- Expand Awareness of these materials to field employees.
- Consider additional maintenance measures such as increased leak surveys in areas of 1^{st} generation PE.
- Repair kits for Aldyl A Delrin Tees and Plexco Celcon Cap Replacements
- Research records for pipe and fitting purchases and installation by company area

Mitigative Measures - Awareness

	Aldyl A	DuPont, Uponor	PE 2306, PE 2406
	Aldyl AAAA[1]	DuPont	PE 2406
	PE (Medium Density)	Plexco pipe, Driscopipe	PE 2306, PE 2406
	PE (Medium Density)[3]	Plexco pipe, Driscopipe, Performance Pipe	PE 2306, PE 2406, PE 2708
	High Density PE	Charter Plastics, W.L. Plastics, Performance Pipe, J.M Manufacturing, Endot, Quail Pipe, Extron	PE 3408, PE 4710
	High Density PE	Performance Pipe	PE 3408, PE 4710
	PA 11	Arkema Inc.	PA 11
	PVC	Various	N/A

Aldyl A Delrin Insert Tapping Tee Repair Kit



Questions?

- Useful Sources:
  - PPDC
  - ADB-99-01 Pre-1973 pipes sold by Century Utility Products brittle-like cracking.
  - ADB-99-02 Plastic Pipe installed between 1960 and early 1980s.
  - ADB-02-07 Warns of premature brittle-like cracking caused by rock impingement, shear/bending stresses, and squeeze-off.
  - ADB-07-01 adds Delrin insert tap tees and Plexco service tee Celcon caps to list identified in ADB-02-07.
  - 1998 NTSB Brittle-Like Cracking in Plastic Pipe for Gas Service
  - 2009 GTI Plastic Pipe Failure Analysis
  - AGA Historic Guide to Aldyl-A Piping

Appendix - Aldyl A By Resin

Period of Manufacture	Approx. Installation Year	Resin	Co-monomer	ASTM	Color	Density [g/cm^3]	SCG Resist./PENT [hours]**	Mean-Time-To-Failure (MTTF) [years] ***	Melt Index (MI) ****	Comments
1965 - 1970	1965 - 1972	Alathon 5040	Butene	PE 2306	Tan/ gray	0.933			1.9	Pipe prone to failure at squeeze off points and rock impingement points.
1970 - 1972	1970 - 1974	Alathon 5043 (LDIW*)	Butene	PE 2306	Tan/ gray	0.938	10	144	1.2	Due to manufacturing issue, pipe has low fracture resistance and is referred to low ductile inner wall (LDIW)
1970 - 1983	1970 - 1984	Alathon 5043	Butene	PE 2306	Tan/ gray	0.938	100	1318	1.2	
1975 - 1983	1975 - 1984	Alathon 5043 “AAAA”	Butene	PE 2306	Green	0.938	100	1318	1.2	The green color is to designate SDR 9.3
1984 - 1988	1984 - 1990	Alathon 5046-C	Octane	PE 2406	Tan	0.938	1000	8094	1.1	Marketed as "Improved Aldyl A"
1988 - 1992	1988 - 1994	Alathon 5046-U	Octane (increased)	PE 2406	Tan	0.933	10,000	n/a	1.1	Also marketed as "Improved Aldyl A"
1992 - 1999	1992 - 2001	Alathon 5046-O	Octane (different type and increased)	PE 2406	Tan	0.933	>10,000	n/a	1.1	Has similar life expectancy as Plexco 2406 and Driscoplex 6500 2406.