Fundamentals of Hydrostatic Testing

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Hydrostatic Testing

- Strength Test – Initial Installation
- Integrity Test – Manufacturing and Construction-Related Threats
- Integrity Test – Cracking including Environmental and Stress Corrosion Cracking

Afternoon Quiz - Are there reasons an operator would not have records for pressure tests conducted before 1970?

Strength Tests – To Establish or Reconfirm MAOP

- Gas Pipelines – Subpart J
- Referred to as a “Proof Test”
- Duration
  - 8 hours
  - Except fabricated assemblies – 4 hours
  - Pre-1970 tests could have been an hour or less
- Strength is established during initial period until pressure is stabilized
  - Duration to establish strength depends on length of test segment
  - Strength is proven when the segment pressure stabilizes
- Multiple hours that follow are to detect leaks
- Strength tests are an option under 192.624 – MAOP* Reconfirmation

* - MAOP – maximum allowable operating pressure – 49 CFR 192.619

Integrity Test – Manufacturing and Construction-Related Threats

- Gas Pipelines – Subpart J
- Duration
  - 8 hours
  - Except fabricated assemblies – 4 hours

- While tests can apply to identify construction defects, note that girth weld only experiences about 40% of the applied stress

Strength Test – Test Levels as Percent of Specified Minimum Yield Strength

- Class 1 – prior to July 1, 2022, was 1.1 x MAOP; after – 1.25 x MAOP
  - If a building intended for human occupancy within 300 feet – 1.25 x MAOP
- Class 2 - 1.25 x MAOP
- Class 3 - 1.5 x MAOP
- Class 4 - 1.5 x MAOP
- Compressor and meter/ regulator stations - 1.5 x MAOP

- Pipe installed prior to Nov 12, 1970 was allowed to have a 1.4 x MAOP test
- Maximum safe test pressure in a test segment - ~110 % SMYS

Integrity Test – Cracking Including Environmental and Stress Corrosion Cracking

- Spike Test
- Short Duration
  - Published standards show 10 minutes to an hour of spike
  - Duration to establish strength depends on length of test segment
  - Integrity is proven after a when the segment pressure stabilizes
- Test Level is Critical – at least 100% SMYS
- Spike testing requirements are found in 49 CFR 192.506
  - 40 CFR 192.506(a)(4) states spike must be held at least 15 minutes after the pressure stabilizes.
- A lower stress level (i.e., 100% SMYS can be use BUT the reinspection interval will be shorter)

Flanges and Flanges Fittings
ASME B16.5

- “Flanged joints and flanged fittings may be subjected to system hydrostatic tests at a pressure of 1.5 times the 38°C (100°F) rating rounded off to the next higher 1 bar (25 psi) increment. Testing at any higher pressure is the responsibility of the user, taking into account the requirements of the applicable code or regulation.”
- ANSI 600 Flange Pressure Rating is 1,480 psig (up to 100^{o}F)
- Maximum test pressure is 1.5 x 1,480 = 2,225 psig

Key point is to ensure fittings are not tested above 1.5 x rating

Records (49 CFR 192.517)

1. The operator's name, the name of the operator's employee responsible for making the test, and the name of any test company used.
2. Test medium used.
3. Test pressure.
4. Test duration.
5. Pressure recording charts, or other record of pressure readings.
6. Elevation variations, whenever significant for the particular test.
7. Leaks and failures noted and their disposition.

Must be kept for the life of the pipeline.

Note: Prior to 1970 (Initial PLS Regulations)

Records required under ASME B31.8

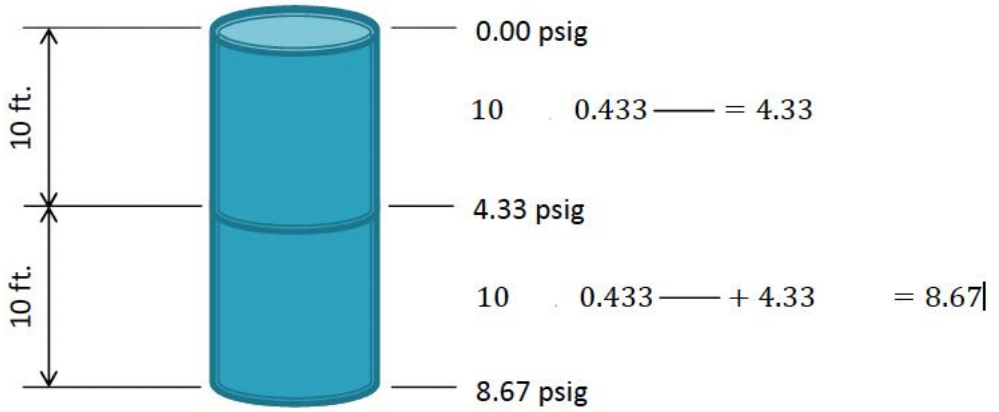
- Pressure
- Medium (water or air)

Important point in evaluating records prior to regulations

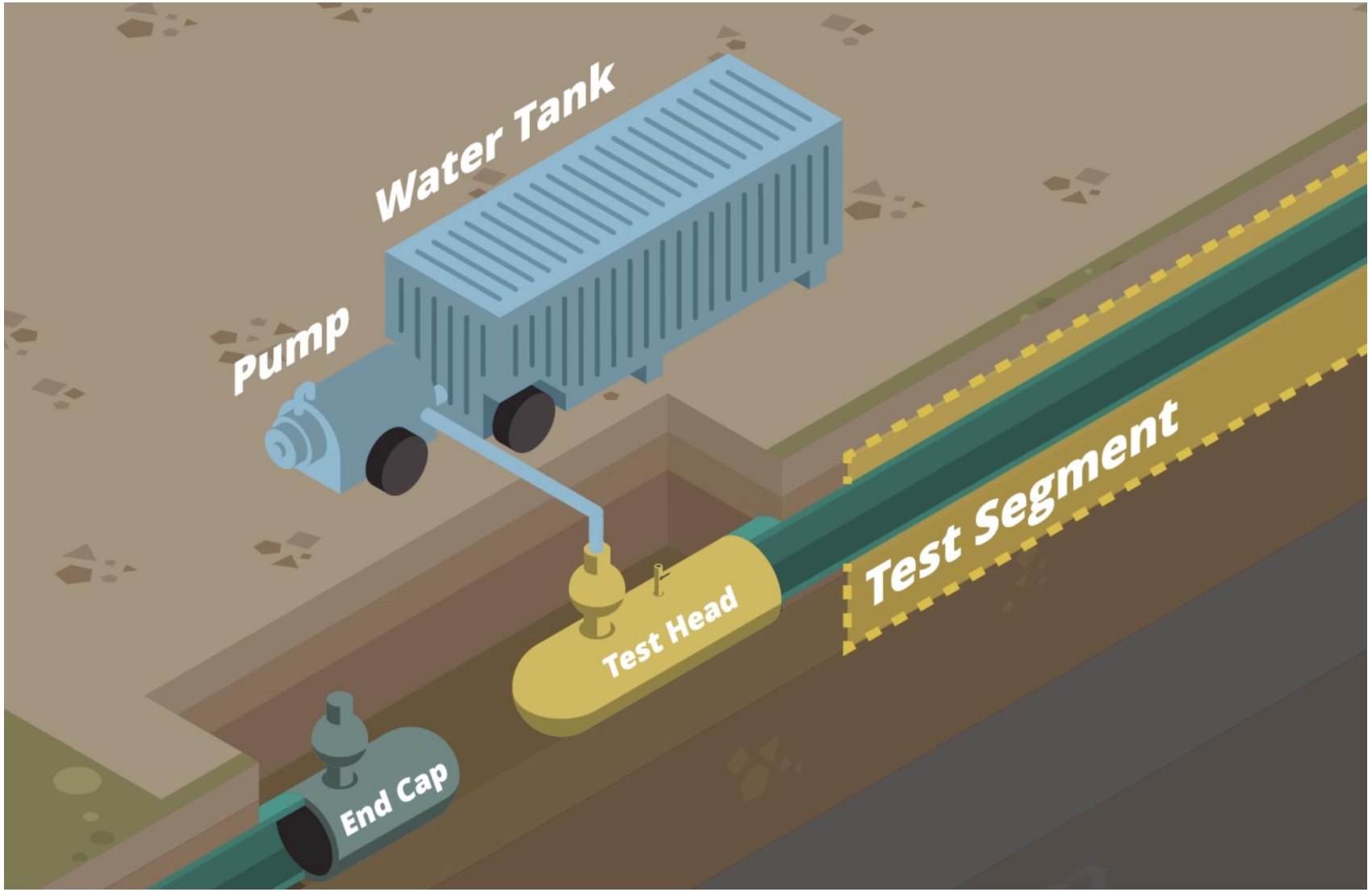
Test Pressure Design & Elevation Adjustment

Pipeline Elevation Profile & Hydrostatic Head

- Hydrostatic Head
  - Water has a unit weight of 62.4 lbs/ft3
  - Therefore, each foot of water in a column exhibits 62.4 lbs/ft2 below it, or 0.433 lbs/in2
  - This can be expressed as 0.433 psig / ft



Pressure Testing – Test Set Up



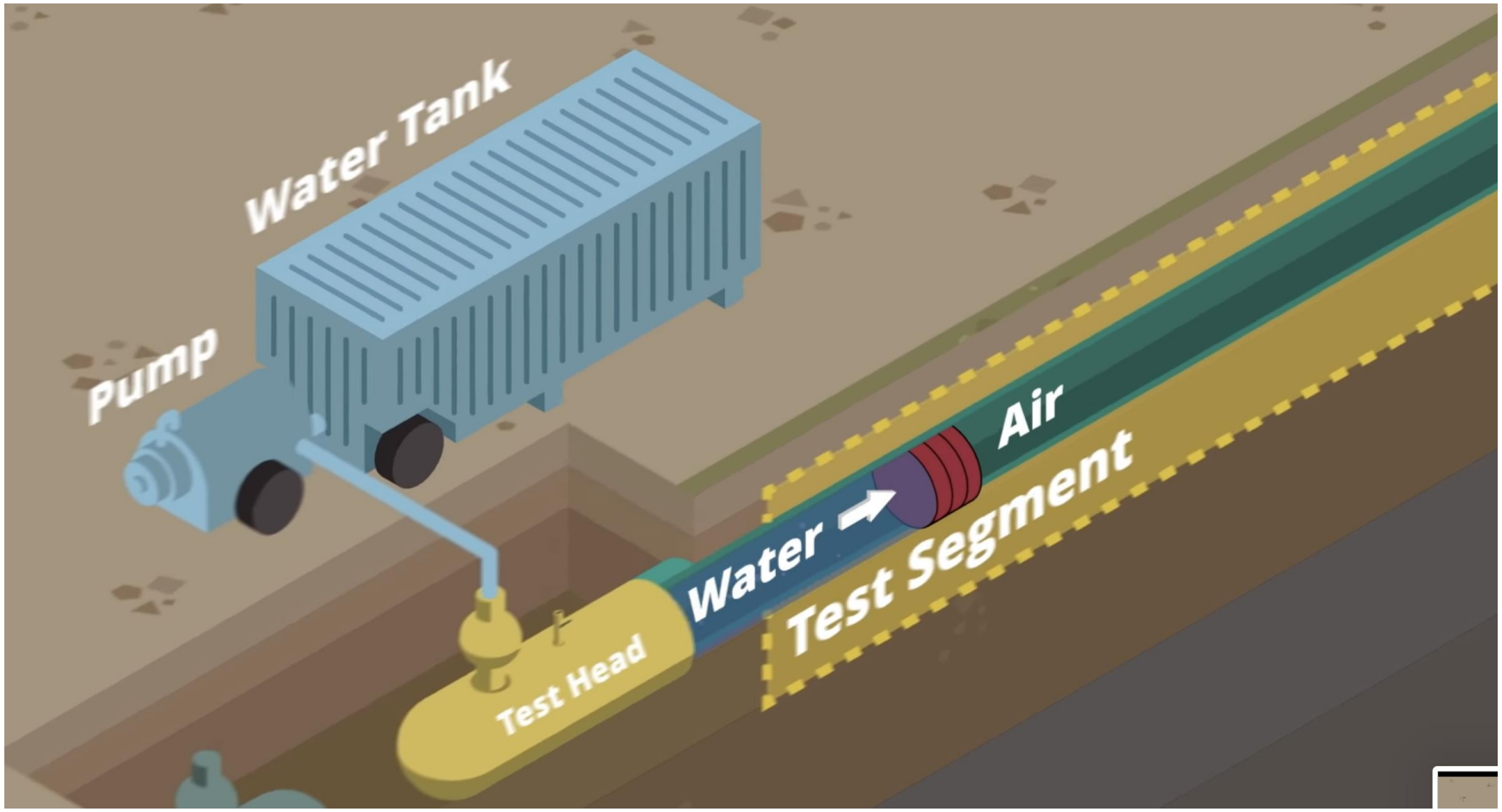
Hydrostatic Test Pressure Design

Pipeline Elevation Profile & Hydrostatic Head

- Hydrostatic Head
  - Example: If a pressure gauge on a pipeline filled with water reads 1,000 psig, what will the pressure be at a location, along the pipeline, 100 feet below?
    - 1,000 + 100 × 0.433 / = 1,043.3
  - Likewise, what will the pressure be at a location 100 feet above?
    - 1,000 – 100 × 0.433 / = 956.7

Note: Hydrostatic Head is independent of slope of pipe, etc. It only matters how many vertical feet of water is below.

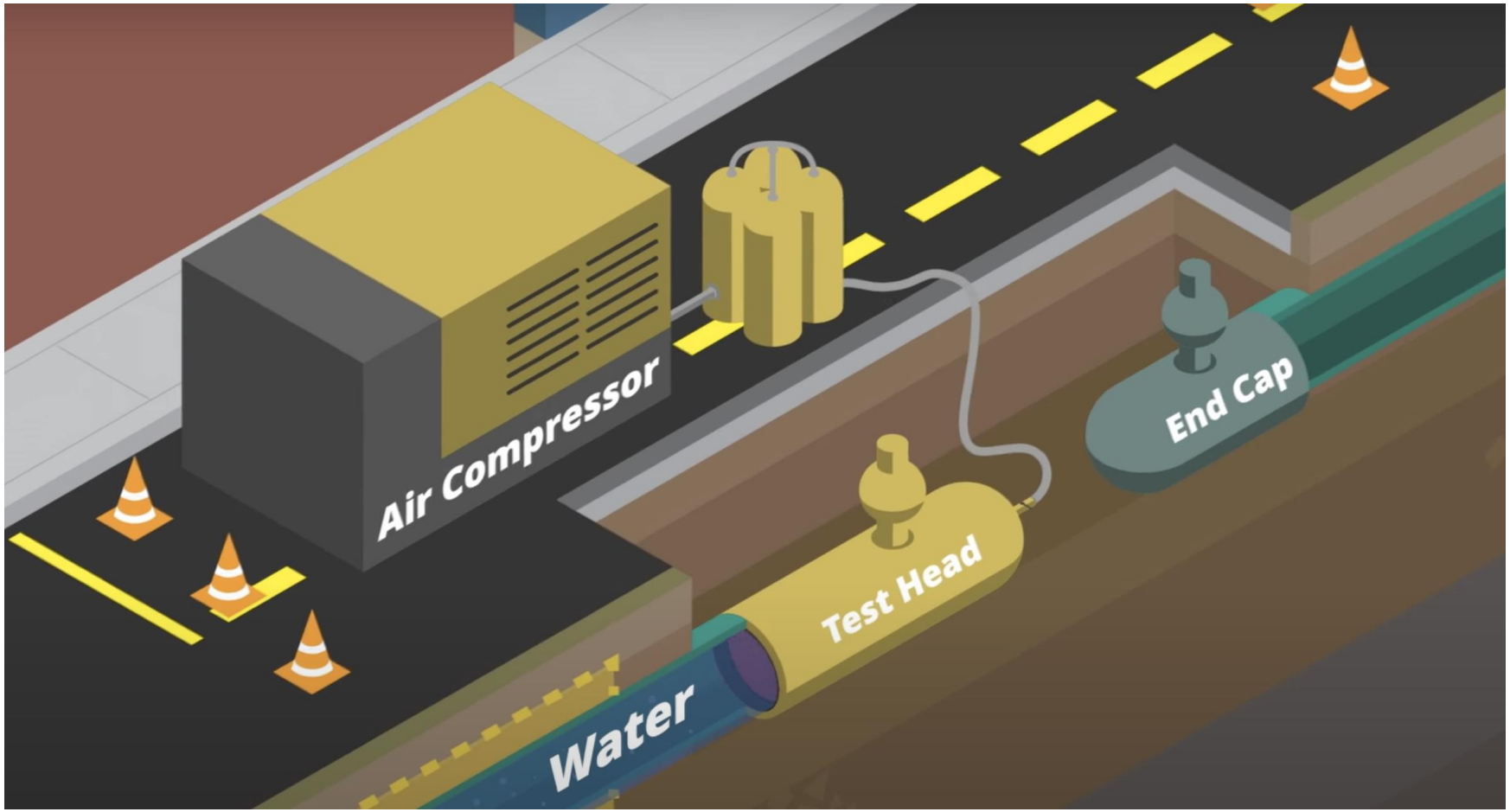
Pressure Testing – Line Fill



Hydrostatic Test Set Up – Filling the Pipeline

- Filling the pipeline with water should be done slowly and in a controlled manner to eliminate any shock to the system and remove any trapped air.
- Often pigs (foam) are pushed ahead to keep the water column intact to prevent mixing.
- The water can, especially on large diameter and/or long pipelines, take hours to stabilize.
- Often a chart is placed on the test header during fill to observe the stabilization.
- Water should be clean and free of debris. Depending on source & quality, water may require chemical treatment.
- Pressure up in stages to reduce shock to system. Allow segment to stabilize.

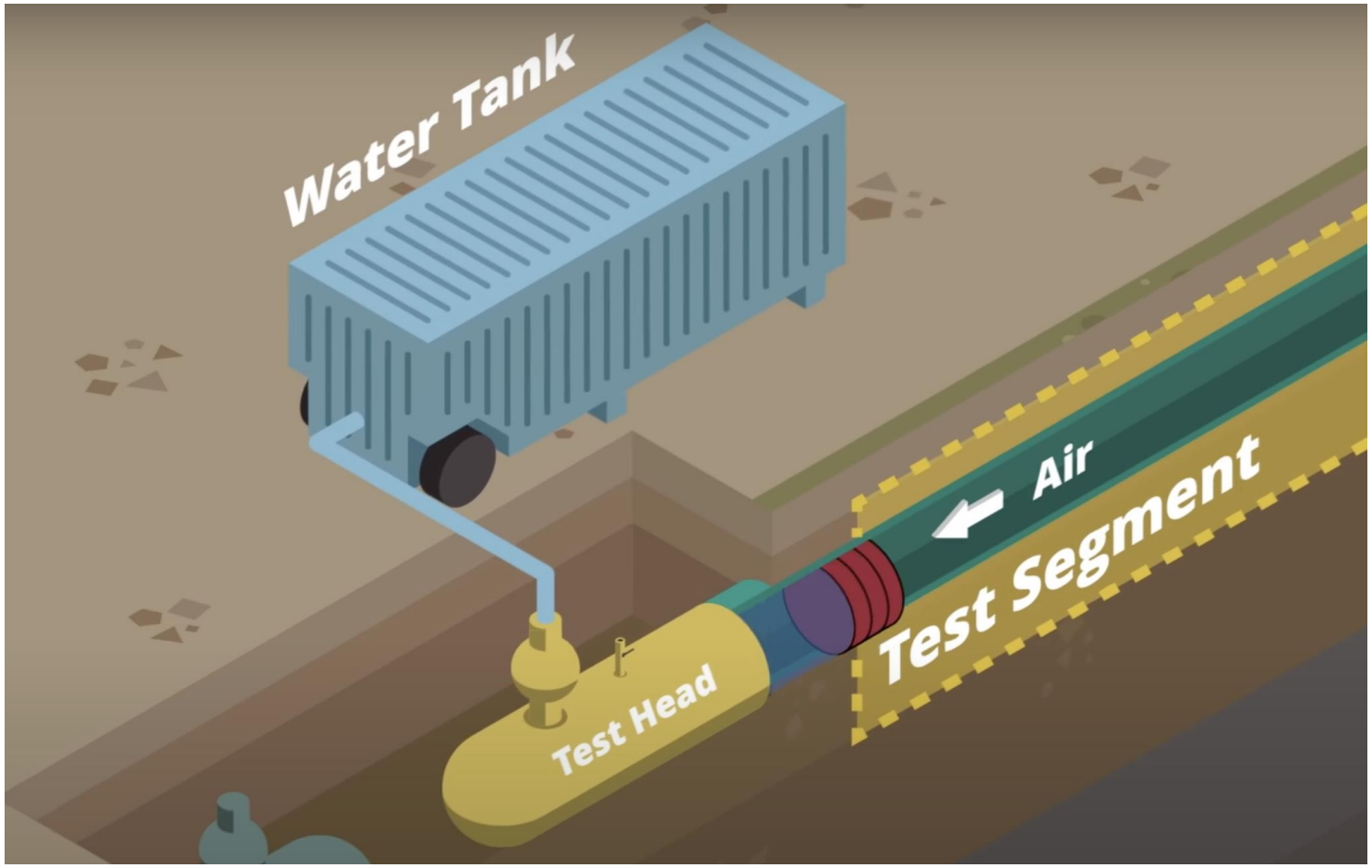
After Testing - Dewatering



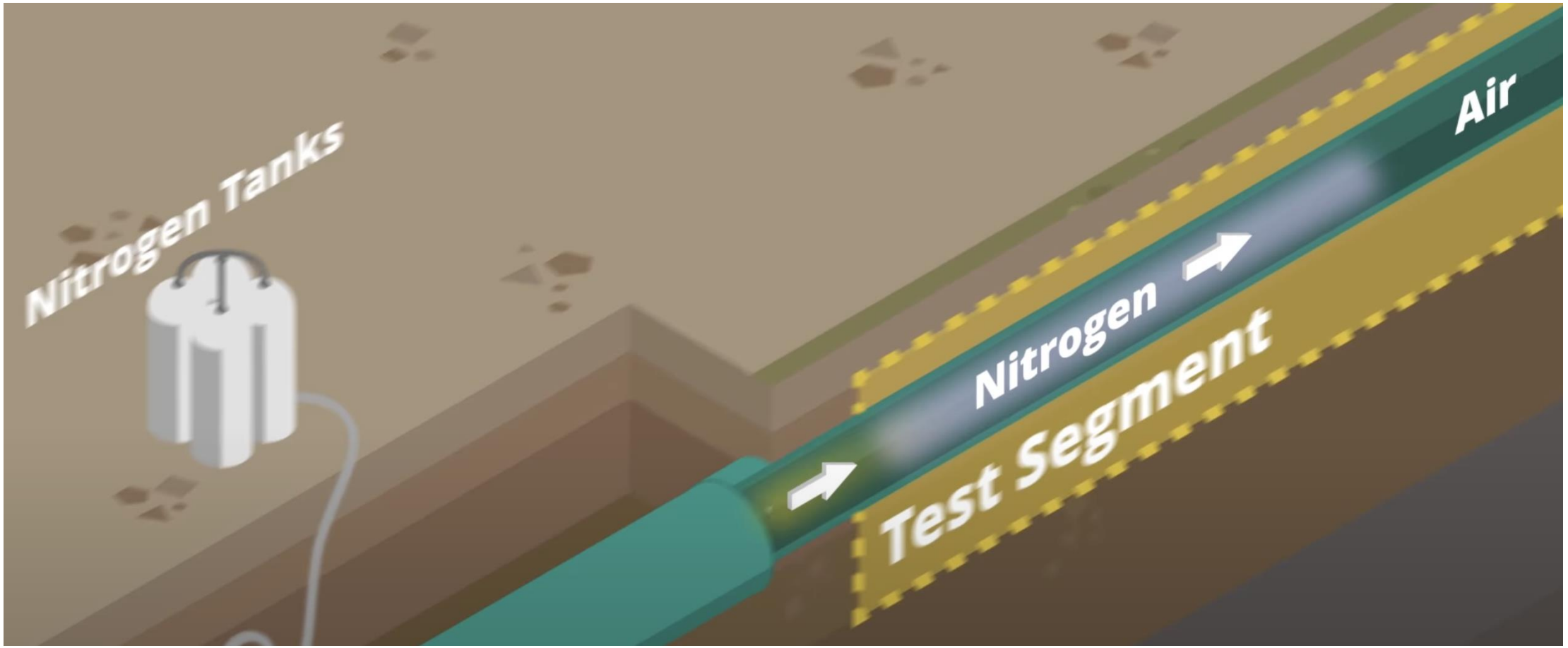
Dewatering

- Dewatering the pipeline should be done slowly and in a controlled manner.
- Poly pigs and/or squeegee pigs are used to push the water towards the dewatering location(s).
- Foam pigs are used to soak up any excess water remaining.

Dewatering - Continued



Purging with Air and Then Nitrogen



Test Acceptance - Scrutinize Carefully

To accept a hydrostatic pressure test, the following items should be considered:

- Test chart and/or pressure gauge depict pressures within the test range for a continuous eight (8) hours
- Consider use of pressure / volume plot
- All equipment calibration records are current and accounted for
- No leaks were found, per §192.503(a)(2)
  - Any rise or fall in pressure must be able to be directly attributed to temperature, weather, precipitation, etc. (i.e., not a leak)
  - In cases where pressure drops are thought to be attributed to temperature, review all data and make the final determination
  - If no determination can be justified, the test may be extended until the pressure is observed to continuously and consistently rise (as temperatures increase)
  - Some operators will make a determination of no leaks if the test pressure is found to not fall over a continuous one (1) hour period. This could be followed up with a leak survey after commissioning as additional assurance.

Water Supply and Disposal

- Water from drinking water supplies ideal given high quality
  - Permit or agreement typically required
- Water from streams, ponds, etc. may introduce silt, sand, debris, and bacteria
  - Permit may be required (e.g., water withdrawal permit)
  - Debris can be strained out prior to introduction to pipeline
  - Presence of bacteria requires chemical treating
- Water discharged overland or back into streams
  - Permit typically required (e.g., State EPA Hydrostatic Discharge Permit)
  - Water must be collected and tested
    - Requirements may differ for new pipelines vs. used pipelines
  - Environmental controls required to eliminate erosion
- Water discharged to tanks and disposed of off site
  - Water must be disposed of at approved site
  - Can be less expensive and quicker process on smaller jobs

General Safety

Communication

- Personnel on site should have readily available means of communication with all other personnel involved
- Examples include radios, cellphones, line-of-sight visual as needed, etc.
- Apply public engagement – notification as per procedures

Boundaries & Barriers

- Barriers, tape, fencing, etc. should be erected around the test area
- Stage personnel and/or erect signs at all points of ingress along the pipeline to warn of the test/restrict access
- All non-essential personnel and the public should be kept at a safe distance
- Only essential personnel should be allowed in the test area and should only remain there as needed to safely and effectively operate the test.
- In special circumstances, equipment may be used to act as a barrier between the test area and nearby structures

General Safety

- Keep equipment in good, safe operating condition and calibration
- Keep hoses, pipes, etc., out of traveled areas, covered, or well-marked to avoid tripping hazards

A Final Thought in Establishing and Reconfirming MAOP

- MAOP is determined under 192.619(a) as the lowest of:
  1. Design basis
  2. Pressure test
  3. Highest operating pressure over prior five years
  4. Condition based on historical review

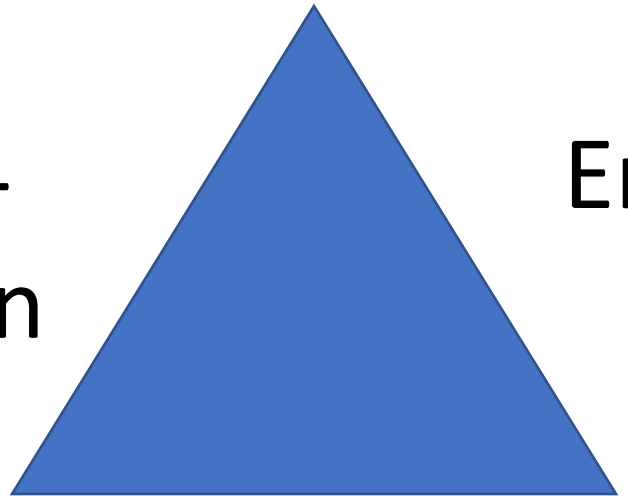
Consider testing slightly above the MAOP x Test Factor so that design basis is clearly the “lowest of.”

For example, if design basis yields an MAOP of 1,000 psi

Considering testing to 1.25 x MAOP + 10 psi in class 1 and 2, and 1.5 x MAOP + 10 psi in Class 3 and 4

Integrity Assessment Methods Can Be Complimentary

Condition -
In-Line Inspection



Environment -
Direct Assessment

Strength -
Hydrotest

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- Design basis for MAOP was design, the lowest of, so operator did not save records for the other three.
- Records for parameters other than “pressure” and “medium” were not required prior to 1970.
- State inspector took pressure test charts and or table of pressures.
- Records may have been lost in the sale of an asset.

Questions and

Discussion

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Resource: Pressure Testing (Hydrostatic & Pneumatic) Safety Guidelines, Revision 1, 2018, INGAA Foundation