17 Piping

17.1 Pipe Markings and What They Mean

Manufactured pipe is marked with information that allows tradespeople, inspectors, and engineers to identify exactly what material has been installed. While the specific format varies by manufacturer, most carbon steel pipe contains a series of markings printed, stenciled, or rolled onto the outside surface.

A typical marking might look something like:

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ABC PIPE
ASTM A106 GR B
ASME SA106 GR B
NPS 2 SCH 80
SMLS
HEAT 12345
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17.1.1 Common Markings

Manufacturer Name
: Identifies who produced the pipe.

ASTM / ASME Specification
: Identifies the material standard. ASTM A106 and ASME SA106 are essentially the same material specification, with the ASME designation being adopted for pressure-retaining equipment and piping constructed under ASME codes.

Grade
: Identifies the material grade. For example, Grade B is commonly used in steam and process piping.

NPS (Nominal Pipe Size)
: Indicates the nominal pipe size, such as 1", 1-1/2", or 2".

Schedule
: Indicates wall thickness, such as Schedule 40 or Schedule 80.

Manufacturing Method
: May include designations such as:
  - ERW (Electric Resistance Welded)
  - SMLS (Seamless)
  - EFW (Electric Fusion Welded)

Heat Number
: A unique identifier that links the pipe back to the steel mill's production records and material test reports (MTRs).

17.1.2 Why the Heat Number Matters

Of all the markings on a pipe, the **heat number** is often the most important from a quality-control perspective.

During steel production, each batch (or "heat") of steel receives a unique number. The material properties, chemical composition, and test results for that batch are recorded on a **Material Test Report (MTR)**.

By matching the heat number on the pipe to the heat number on the MTR, an inspector can verify:

- The correct material was supplied.
- The pipe meets the required specification.
- The chemical composition is acceptable.
- Mechanical test results meet code requirements.

17.1.3 Why Pipefitters Should Care

A pipe marking is much more than a label. It tells you:

- What size the pipe is.
- How thick the wall is.
- What material it is made from.
- How it was manufactured.
- Which MTR belongs to it.

When pipe is cut into short pieces, good shops often transfer the heat number to each remaining piece so traceability is not lost. Once the markings are removed or painted over without being transferred, proving material compliance can become difficult or impossible.

17.1.4 Key Takeaway

The markings printed on a pipe are its identity card. They provide the information needed to confirm size, schedule, material specification, manufacturing method, and traceability back to the original Material Test Report. For work performed under ASME, CSA, or other quality systems, preserving these markings is often just as important as making a good fit-up or weld.

This process is known as **material traceability**.

The heat number is the link between the physical pipe and the documentation that proves its compliance. The document used for this purpose is the Material Test Report (MTR), which will be discussed in the next section.

17.2 Schedule 40 vs. Schedule 80

One of the first surprises for new pipefitters is that **nominal pipe size (NPS)** is not the actual inside or outside diameter. For a given NPS, the **outside diameter (OD) remains constant** regardless of schedule. As wall thickness increases, the **inside diameter (ID) decreases**, reducing flow area and increasing pressure capability.

The term "nominal" means the size is a designation rather than an actual measurement. For example, a 2" pipe does not measure 2" outside diameter or 2" inside diameter. It is simply identified as NPS 2, and the actual dimensions are defined by published standards.

For steam systems, the practical difference between Schedule 40 and Schedule 80 is usually:

- Schedule 80 has thicker walls and greater pressure tolerance.
- Schedule 80 is heavier and more expensive.
- Schedule 80 has a smaller internal flow area, which increases velocity for a given flow rate.
- Most low- and medium-pressure steam systems use Schedule 40 unless design conditions require the additional wall thickness.

17.2.1 Common Small-Bore Pipe Sizes

NPS	OD (in.)	Sch 40 Wall (in.)	Sch 40 ID (in.)	Sch 80 Wall (in.)	Sch 80 ID (in.)
1/2"	0.840	0.109	0.622	0.147	0.546
3/4"	1.050	0.113	0.824	0.154	0.742
1"	1.315	0.133	1.049	0.179	0.957
1-1/4"	1.660	0.140	1.380	0.191	1.278

NPS	OD (in.)	Sch 40 Wall (in.)	Sch 40 ID (in.)	Sch 80 Wall (in.)	Sch 80 ID (in.)
1-1/2"	1.900	0.145	1.610	0.200	1.500
2"	2.375	0.154	2.067	0.218	1.939

Source dimensions from ASME B36.10 pipe schedules. 【1-d8d563】【2-b99ff3】【4-b548f6】

17.2.2 Internal Flow Area Comparison

The reduction in flow area is often more significant than people expect.

NPS	Sch 40 Area (in²)	Sch 80 Area (in²)	Reduction
1/2"	0.304	0.234	23.0%
3/4"	0.533	0.432	18.9%
1"	0.864	0.719	16.8%
1-1/4"	1.496	1.283	14.2%
1-1/2"	2.036	1.767	13.2%
2"	3.356	2.953	12.0%

Flow area calculated as $A = \pi D^2/4$ using the published inside diameters. 【1-d8d563】【2-b99ff3】

17.2.3 Key Takeaway

Notice that while the OD never changes, a 1/2" Schedule 80 pipe has roughly **23% less flow area** than a 1/2" Schedule 40 pipe. The difference becomes less pronounced as pipe size increases, but even at 2" there is still about a **12% reduction in flow area**. This is why pipe schedule affects not only pressure rating but also fluid velocity and system performance.

Because a Schedule 80 pipe has a smaller internal diameter than a Schedule 40 pipe of the same nominal size, steam velocity increases for the same flow rate. A 1" Schedule 80 pipe carries steam about 20% faster than a 1" Schedule 40 pipe, while a 1/2" Schedule 80 pipe carries it about 30% faster. This increase in velocity results in greater pressure loss, noise, and potential erosion within the piping system.

Since velocity is inversely proportional to flow area:

$$V = \frac{Q}{A}$$

A reduction in area always results in an increase in velocity when flow rate remains constant.

17.3 Threaded Pipe Connections

Before welded systems became commonplace, much of the steam industry was built using threaded pipe. Even today, small-bore steam piping (typically 2" NPS and below) is frequently assembled using threaded fittings.

A threaded connection is created by machining a helical groove—called a **thread**—onto the outside of a pipe and the inside of a fitting. As the pipe is screwed into the fitting, the mating threads pull the components together and create a pressure-tight joint.

17.3.1 National Pipe Thread (NPT)

The most common thread form used in North America is **National Pipe Taper (NPT)**.

Unlike a machine bolt, which has straight threads, NPT threads are tapered. Both the male and female threads become slightly narrower toward the end. As the connection is tightened, the threads wedge together, creating the seal.

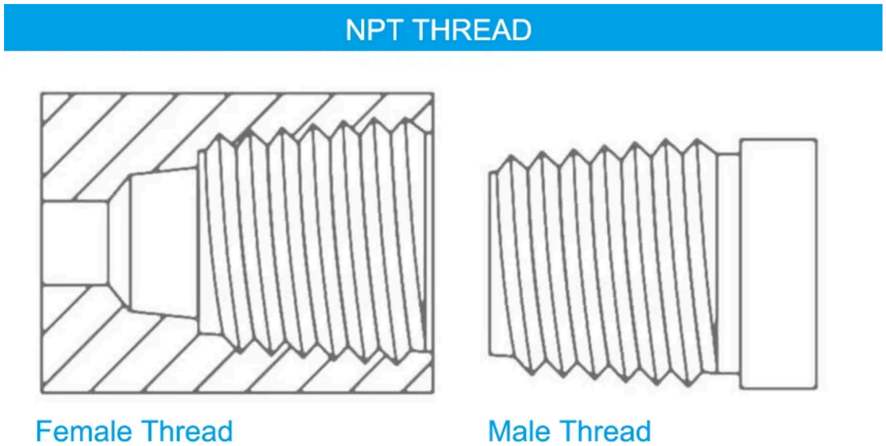

Fig. 1 NPT male and female thread

The taper is approximately 1 in 16, meaning the diameter changes by 1 inch over 16 inches of thread length.

17.3.2 How Threads Are Cut

Pipe threads are usually cut using a manual ratchet threader or a powered threading machine.

The process is straightforward:

1. Cut the pipe square.
2. Ream the inside to remove burrs.
3. Secure the pipe in the threader.
4. Apply cutting oil.
5. Advance the die head onto the pipe.
6. Cut until the thread reaches the proper length.
7. Clean and inspect the threads.

A properly cut thread will:

- Have a smooth finish.
- Show no torn or flattened crests.
- Allow hand-tight engagement for several turns.
- Tighten progressively as the taper engages.

17.3.3 Thread Engagement

A common misconception is that the seal occurs at the end of the pipe. In reality, the seal forms along the flanks of the tapered threads as they wedge together during tightening.

```
          Seal occurs here
                 ↓
    /\/\/\/\/\/\/\/\/\
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 Pipe             Fitting
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NPT threads are designed to seal through the tapered interference of the mating threads. As the joint is tightened, the thread flanks wedge together, producing metal-to-metal contact and slight deformation that forms the primary seal. Thread sealants such as PTFE tape or pipe dope are used to lubricate assembly and fill microscopic leak paths that remain due to manufacturing tolerances and surface roughness.

17.3.4 Schedule 40 vs. Schedule 80 and Threading

An interesting consequence of thicker pipe walls is that Schedule 80 pipe develops deeper, stronger threads than Schedule 40 pipe.

Because more metal remains beneath the thread root:

- Thread strength increases.
- Resistance to thread damage improves.
- The connection is generally better suited to higher-pressure service.

On smaller pipe sizes, this difference is easy to see when comparing freshly cut threads side by side.

This is one reason Schedule 80 threaded piping is often specified where pressure, temperature, or mechanical stresses exceed the limits of Schedule 40.

17.3.5 Thread Sealants

Although the tapered threads provide the primary seal, standard NPT threads contain microscopic leak paths caused by manufacturing tolerances and surface roughness.

Thread sealants serve two important purposes:

- Filling spiral leak paths.
- Lubricating the threads during assembly.

Common sealants include:

- PTFE (Teflon) tape
- Pipe dope (thread compound)
- PTFE tape combined with pipe dope

For steam service, the sealant must be rated for the system temperature and pressure.

It is worth noting the difference between standard NPT and NPTF (National Pipe Taper Fuel, commonly called Dryseal pipe thread). In NPTF connections, the thread roots and crests are designed to deliberately crush and deform into each other during tightening. This metal-to-metal deformation completely eliminates the spiral leak path, allowing for a mechanical "dry seal" without requiring tape or paste (though lubricant is still often used to ease installation).

17.3.6 Why Overtightening Is a Problem

New pipefitters are often tempted to tighten threaded joints as much as possible. Excessive torque can:

- Crack cast-iron fittings.
- Distort valve bodies.
- Damage thread profiles.
- Make future disassembly extremely difficult.

The objective is not maximum torque; it is proper thread engagement and sealing.

17.3.7 Galling in Threaded Joints

Galling is a form of severe adhesive wear in which two metal surfaces slide against one another under pressure and small portions of the two metals cold-weld together. As the joint continues to turn, these microscopic welds tear apart, transferring material between the threads. In practical terms, galling is a form of metal-to-metal seizure.

Fig. 2 Galling

Pipe dope and PTFE tape are not just sealants—they are also lubricants that reduce friction, prevent galling, and allow the tapered threads to seat properly.

A small amount of thread deformation is expected and desirable in an NPT joint. Galling is excessive, uncontrolled deformation that damages the threads.

17.3.8 Why Galling Occurs

Galling is promoted by:

- High contact pressure
- Lack of lubrication
- Repeated assembly and disassembly
- Similar metals rubbing together
- Soft, ductile materials

It is particularly common with:

- Stainless-steel fasteners
- Stainless threaded pipe fittings
- Brass and bronze components
- High-torque threaded connections

Carbon steel pipe generally experiences less galling than stainless steel, but it is not immune.

17.3.9 What It Looks Like

A galled thread often appears:

- Rough and torn
- Smeared or scored
- Covered with metallic debris
- Difficult or impossible to turn

In severe cases, the threads effectively seize together.

Many mechanics have experienced a stainless bolt that suddenly becomes impossible to turn in either direction. That is classic galling.

17.3.10 Why Pipefitters Care

When assembling threaded pipe, friction between the mating threads can become very high.

Without a lubricant:

- More torque is required.
- Threads can tear or deform.
- Proper engagement may not be achieved.
- Disassembly becomes difficult years later.

This is one reason thread compounds are valuable even when the threads themselves provide the primary seal.

17.3.11 How Pipe Dope and PTFE Tape Help

Thread sealants serve several functions:

1. Fill microscopic leak paths.
2. Lubricate the threads.
3. Reduce friction during assembly.
4. Minimize galling and thread damage.
5. Allow deeper thread engagement before excessive torque develops.

A lubricated NPT joint typically tightens farther than a dry joint using the same wrench force. The result is often a better mechanical seal and less damage to the threads.

17.3.12 Key Takeaway

A threaded connection seals because tapered male and female threads wedge together as they are tightened. The threads provide mechanical strength, while a thread sealant fills the microscopic leak paths that would otherwise allow steam, water, or air to escape. Proper thread cutting, adequate engagement, and avoiding overtightening are essential skills for reliable piping work.