TECHNICAL PAPER

THE CASE FOR METAL CAPILLARY HOSES IN HIGH PRESSURE AND HYDRAULIC TEST CIRCUITS

By: Barry Singer

6421 Independence Ave. Woodland Hills, CA 91367
PH: (818) 877-5460 • www.kingnutronics.com

INTRODUCTION

In a pressure test circuit, particular attention is given to the accuracy and precision of the reference device, and of the ability of the pressure source to provide the required test pressure. However there is one other factor that is sometimes overlooked, and can influence the outcome of the test. That factor is stability.

FACTORS AFFECTING STABILITY

There are a few factors which can influence the stability in pressure test circuits. Understanding these. variables will help you to identify the difference between them, and to safeguard against them for better calibration results.

LEAKS

Leaks may be very small but can affect the pressure reading immensely. In hydraulic test circuits, the effects of leaks are more pronounced than in pneumatic test circuits. The bottom line, leaks in any test circuit will make pressure readings difficult. Best practices should always be used to prevent leaks in the test circuit, and system integrity should be verified before starting a test.

ADIABATIC EFFECT

When system leaks are ruled out, the most common cause of instability is the result of temperature changes in the test circuit as pressure is increased or decreased. This effect is called Adiabatic. The pressure medium (gas or liquid) will change temperature as it's compressed or uncompressed. As the temperature equalizes with the surroundings, the pressure of the medium will change

MATERIALS

The third most common factor contributing to instability is due to the types of materials used to contain the test pressure, and more specifically, with the types of test hoses used to transfer the test pressure between the calibration pump and the device under test (DUT).

TEST HOSE CONSIDERATIONS

When selecting a hose for your application consider the following:

- **Distance to Connection** – The ideal is always to use the shortest possible hose for the test being carried out. The longer the run, the greater volume of pressure medium in the test hose, and the higher likelihood of instability. Limiting of the ability to generate enough test pressure may also occur, this is particularly true of gas pressure medium that compresses fairly easily.

- **Test Site Conditions** – Conditions at the site could affect the ability to achieve a safe and practical test. For example if the hose gets kinked, bent, damaged, or is exposed to heat.

- **Pressure Medium** – The hose must be compatible with the medium being used to generate the test pressure. For example Skydrol is a commonly hydraulic fluid used in the aerospace industry, and is not recommended for use with many synthetic materials.

- **Pressure Source Limitations** – Due to the limitation on how much volume of medium the pressure source can generate it's possible that your pressure source may not be able to generate a high enough test pressure to calibrate the DUT.

- **Pressure Range** – Select a hose that's designed to function correctly within the operating range of the pressure to be applied.

TYPES OF TEST HOSES AVAILABLE

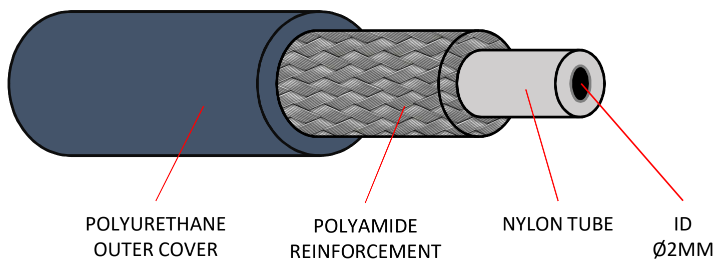
There are many different hose available for calibration and test type applications, the two most common categories to consider are:

SYNTHETIC HOSES

Commonly used for pneumatic testing and for hydraulic pressure testing up to 5,000 PSI. Typically they have an internal core construction of nylon reinforced with polyamide fibers. Most have an internal diameter of 2mm to 3mm. The hose outer cover may be polyurethane or similar for low cost, or something like Kevlar® for high strength. Outer covers may be pinpricked to prevent bubbles or blisters, very important for use in certain applications. Mechanical attachments to end fittings are made with crimp or compression type connections.

ADVANTAGES

- Low Cost
- Easily Repairable
- Small Bend Radius
- Low Weight and Small

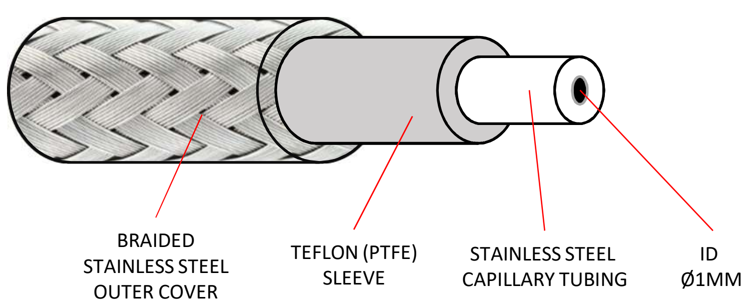


METAL CAPILLARY HOSES

Designed for critical applications, metal capillary hoses may be used up to 10,000 PSI for pneumatic and hydraulic testing. A stainless steel inner core construction is very common. Typical ID of the hose is 1mm or less. The hose is sleeved with a flexible material such as PTFE, and then encased in a stainless steel braid for protection against physical damage. Connections to end fittings are made using braising or welding for suitability in high pressure applications.

ADVANTAGES

- Durable
- Low elasticity/stretching
- Corrosion Resistance
- High Pressure Rating



PERFORMANCE COMPARISON

For a real world comparison we chose four commercially available test hoses and ran the same sequence of testing on all four, refer to Table 1. Our goal was to test the high pressure performance of each hose operated hydraulically. For the purpose of these tests high pressure is defined as over 500 PSI.

HOSES TESTED FOR PERFORMANCE

TABLE 1

Model:	**Model Q**	**Model X**	**Model S**	**King Nutronics (KNC) SuperPressure**
Inner Tubing:	Nylon/Polyamide	Nylon/Polyamide	Nylon/Polyamide	Metal Tubing
Outer Cover:	Not specified	Kevlar	Polyurethane	Stainless Steel Braid
Inner Diameter:	2mm	2mm	2mm	1mm
Rated Pressure:	6,900 PSI	10,000 PSI	9,135 PSI	10,000 PSI
Connection:	Proprietary	AN-4	AN-4	AN-4




The hoses were connected from a King Nutronics Model 3750 hand pump to a pressure gauge stand. A precision pressure gauge was mounted on the gauge stand. As shown in the picture, the hand pump was positioned in a holder to prevent it from moving during the test and influencing the results.

The test circuit was evacuated of air and filled with distilled water. A priming pressure of 500 PSI was generated before each test was started.

High pressure is generated using the volume adjuster knob. This acts as a piston in a cylinder to compress the pressure medium.

PERFORMANCE COMPARISON (continued)

Each hose was tested 3 times and results were recorded. The test procedure as follows:

1. Increase pressure by rotating volume adjuster 2 turns over a period of 10 seconds.
2. Take initial reading.
3. Take subsequent pressure readings after 1, 2, 3, 4, 5, & 10 mins.
4. After 10 mins. volume adjuster rotated back to original position and priming pressure adjust back to 500 PSI.
5. Repeat steps 1-4 for a total of 3 test cycles.

Data from the testing was analyzed to determine 3 performance characteristics:

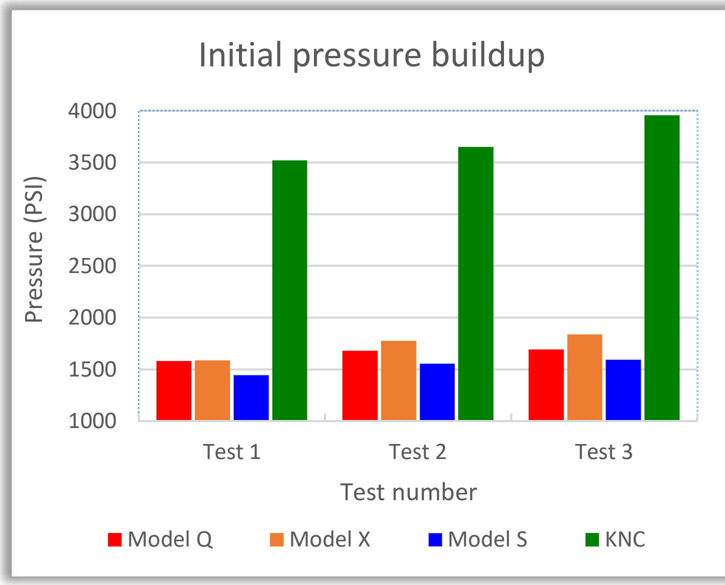
- **Pressure Buildup** Characterized as the maximum pressure generated with a given pumping stroke.
- **Pressure Drop** Characterized as the loss of pressure over time compared to an initial reading.
- **Pressure Stabilization** Characterized as the time taken for the system to stabilize without having to add pumping stroke to maintain a given pressure. A stable reading is defined as a rate of pressure change less than 20 PSI/min.

A digital pressure gauge was used to monitor the pressure decay rate (Δ P). The pressure gauge we used has a secondary reading (shown in red circle) which indicates Δ P in PSI/min.

PERFORMANCE COMPARISON (continued)

PRESSURE GENERATION

Test results varied from hose to hose but consistently each hose recorded higher readings on subsequent tests. However, the comparison from hose to hose was consistent. The metal capillary hose generated at least twice the initial pressure compared to the synthetic hoses.

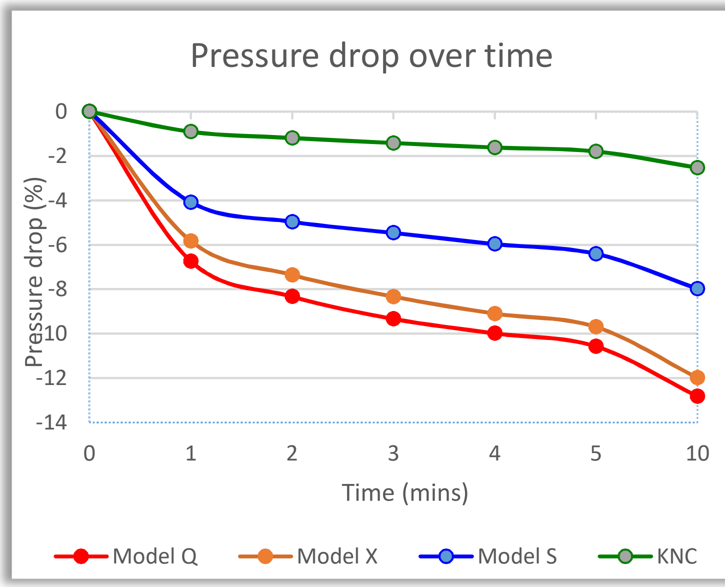


Conclusion: Not surprisingly a hose with smaller ID and lower overall volume allows for a significantly higher pressure generation using the same pump stroke.

PRESSURE DROP

From the data recorded the percentage of pressure drop was calculated and compared to the initial reading.

The greatest pressure drop is seen in the first minute of observation, however from hose to hose the difference is very noticeable. The metal capillary hose pressure dropped typically 2% over a 10 minute period compared to a pressure drop of at least 12% for the synthetic hoses.

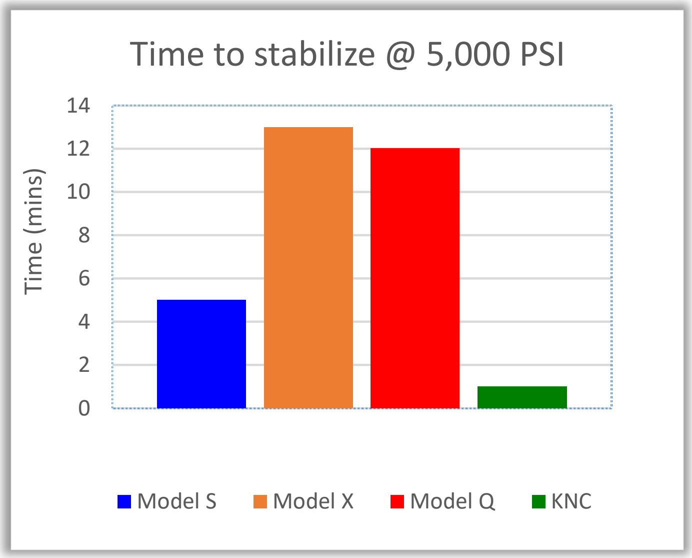


Conclusion: The metal capillary hose pressure loss was noticeably less than the synthetic hoses by at least a factor 4.

PERFORMANCE COMPARISON (continued)

PRESSURE STABILIZATION

The hand pump was adjusted to generate an output pressure of 5,000 PSI and small adjustments were made as necessary to maintain the 5,000 PSI. The time was recorded from the initial 5,000 PSI setting until the output pressure was reasonably stabilized (Δ P <20 PSI/min).



Conclusion: The metal capillary hose stabilized almost immediately, the synthetic hoses took up to 13 minutes to stabilize.

OVERALL CONCLUSION

Synthetic hoses are typically much lower in cost and seem to work just fine for lower pressure (<500 PSI) pneumatic applications. They are also more flexible and easier to work with compared to metal capillary hoses. However, for higher pressures and for hydraulic applications, the performance requirement becomes more critical, and differences in design and construction become more noticeable.

We evaluated these hoses for the ability to build pressure, hold pressure over time, and the time to stabilize. With these objectives in mind, the metal capillary hoses clearly outperform synthetic hoses. Certainly if your requirement is to conduct precise high pressure calibrations efficiently, the metal capillary hose will provide the highest level of performance.