



**PREMIUM SAND SCREEN TESTING  
MECHANICAL STRENGTH TESTS  
MARCH 2004**

*Prepared for:*

**TUBULAR PERFORATING MANUFACTURING LTD.**

*Prepared by:*

**APA (U.S.A.) INC.**

**APRIL 30, 2004**

**PRACTICAL SOLUTIONS  
TO COMPLEX PROBLEMS**

May 10, 2004

Job No. 50185

Tubular Perforating Manufacturing, Ltd.  
P.O. Box 2039  
Conroe, Texas 77305

Attn: Ed Blackburne, Jr.

**Re: PREMIUM SAND SCREEN TESTING REPORT**

---

Dear Ed:

Please find the attached final report documenting the mechanical testing of Tubular Perforating Manufacturing Ltd.'s new premium screen. The testing is preliminary to commercial sales of the screen. While professing an interest in cheaper premium screens, some of those operating companies, surveyed earlier for the marketing analysis, asked about the mechanical properties of the screen. Tubular Perforating Manufacturing Ltd. authorized the mechanical testing of the screen in Mohr Engineering, a division of Stress Engineering Services, Inc.

The screen performed extremely well in all mechanical tests. The results of the tests are documented in this report along with the methodology of testing. From these results, APA believes the screen can hold up to the mechanical stresses and strains that are often incurred when installing the screens in the hole while maintaining its screening integrity. The screen is robust and can withstand a large delta pressure across it to the perforations in the base pipe in the event that the screen should be plugged and require an acid or jetting clean up treatment. Many of the tests were continued until destruction, which will be an advantage to those utilizing the screen in knowing the physical limitations of the screen. Even though the failures were recognized in the shrouds, there was not an indication of a wire mesh integrity problem. This artefact of the test would seem to indicate the robustness of the outer portion of the screen is carried into the inner mesh that is most important in retaining sand.

APA, as a third party witness to these tests, is happy to supply this report as support to the mechanical superiority of Tubular Perforating Manufacturing Ltd.'s premium sand screen.

Yours sincerely,

APA (USA) Inc.



John A. Johnson, P.E.  
Production Specialist

Encl.

---

# TABLE OF CONTENTS

	Page
LETTER OF TRANSMITTAL	
CONCLUSIONS	i
RECOMMENDATIONS	ii
1.0 BACKGROUND	1
2.0 TEST METHODOLOGY	2
3.0 TESTING	4
3.1 Axial Tension Tests	4
3.1.1 Test Procedure	5
3.1.2 Test Results	6
3.2 Axial Compression Tests	7
3.2.1 Test Procedure	8
3.2.2 Test Results	9
3.3 Torsion Tests	10
3.3.1 Test Procedure	11
3.3.2 Test Results	12
3.4 Collapse Tests with Simulated Perforated Base Pipe	13
3.4.1 Test Procedure	13
3.4.2 Test Results	14
4.0 WIRE MESH INFORMATION	16

---

## CONCLUSIONS

1. TPM's proprietary premium screen is robust and can stand up to the rigors of installation in the well.
2. The mechanical test properties were taken on the screen itself where most of the competitors test the screens on base pipe. (When the screens are tested on base pipe, base pipe dominates. A manufacturer's selection of base pipe will directly influence the results of mechanical testing.) This fact should encourage operators to use TPM's premium screen as it has shown to be particularly tough on its own construction in both tensile and compression.
3. Collapse and torque, however, will both be improved with the screen being on base pipe. Collapse is the indicator as it went from 300 psi+ to over 7,500 psi when placed on base pipe. Torque in most cases will be transferred to the base pipe.
4. Operators should feel confident to run TPM's premium screens on to the target zone even if there is significant pull or set down on the production assembly should the screen get stuck on the way in the hole.
5. The collapse test on base pipe with the ports is considered an extreme test because:
  - a. The plugging agent was not sufficient for high differential pressure use.
  - b. It is expected that 7500 psi differential pressure is much higher than will be actually seen across the screen.
  - c. The ports were not arrayed as in normal base pipe, only in 90° phases in one plane and they were not the same size (3/4", 5/8", 1/2", and 3/8").
  - d. The blank surface areas of the test base pipe was not representative of the area over which the pressure acting to deform the screen actually will have in application.

## **RECOMMENDATIONS**

1. Tensile and compression tests should be heralded as significant tests to operators so that they will not be worried about the robustness of the screen.
2. Torque tests reflected no leak when torqued well past the elastic failure of the shrouds. However, APA recommends that base pipe torque limits be used when running screen assemblies in the well.
3. The collapse test on base pipe with the ports should be looked at again for the reasons mentioned in the conclusions. APA feels that 7500 psi is a conservative collapse limit for the screen on base pipe.

---

## 1.0 BACKGROUND

Tubular Perforating Manufacturing Ltd. (TPM) requested APA (U.S.A.) Inc. to conduct a market analysis for their new proprietary designed premium sand screen. An initial sand screen market survey of operating oil companies was completed and given to TPM.

From that analysis, APA recommended that TPM do some initial testing to verify the durability and strength of the TPM screen. Additionally, TPM was advised that some sand retention and plugging information would be of interest to the various operating companies surveyed.

TPM and APA agreed that tension; compression; compaction; torque; and leak integrity tests should be performed at an independent lab. TPM would procure wire mesh through Dorstener Wire Technology and would get information on sand retention and plugging of the mesh. This report documents the results and methodology in acquiring the mechanical test information.

Stress Engineering Services, Houston, Texas; Southwest Research Institute (SwRI), San Antonio, Texas; and Centre for Frontier Engineering Research (C-FER), Alberta, Canada were all contacted with regard to the testing of the screens. Stress Engineering Services were chosen as they had the most complete package of test equipment ready for testing. Stress was also the most convenient test lab to TPM for shipping test samples and witnessing tests.

---

## 2.0 TEST METHODOLOGY

TPM and APA discussed the purpose of testing the screen. The major reason for testing the screen was to have data to prove to prospective clients that the screen was robust enough for them to utilize in their wells. Most mechanical testing is conducted with the base pipe in place and generally reflects the characteristics of the base pipe when testing. That is, the tensile strength measurement is dominated by the base pipe and is routinely found at 95% of the tensile of the base pipe. Likewise the compression and torque measurements are reflective of the base pipe.

TPM and APA determined that testing utilizing base pipe would basically be a comparison of the different base pipes being utilized. The base pipe chosen can reasonably skew the tests. TPM proposes to let clients choose their own base pipe as opposed to TPM affixing the screens to a particular base pipe. In light of this decision, the methodology of the screen tests changed to checking the robustness of the screen itself.

The data we feel is quite usable in the event that the screen is stuck during installation and the screen is the point where the sticking occurs. The question is how much weight can you pull or set down on the screen without creating some damage to the screen. If the operator can pull or set down a certain amount that is less than the elastic limit of the screen and does not create a leak path, it is safe to assume the screen will be able to carry out its responsibility with out pulling out of the hole to check the integrity. This information will allow the operator to run on in the hole and save rig time and expense. Likewise, the maximum torque on the screen was also tested.

Each of these mechanical strength tests was completed with a pump-in test occurring simultaneous to the forces being applied to the screen. We reasoned that if the test did not create a leak path, then the screen was robust enough to handle the abuse applied to it without losing integrity until the point that the force

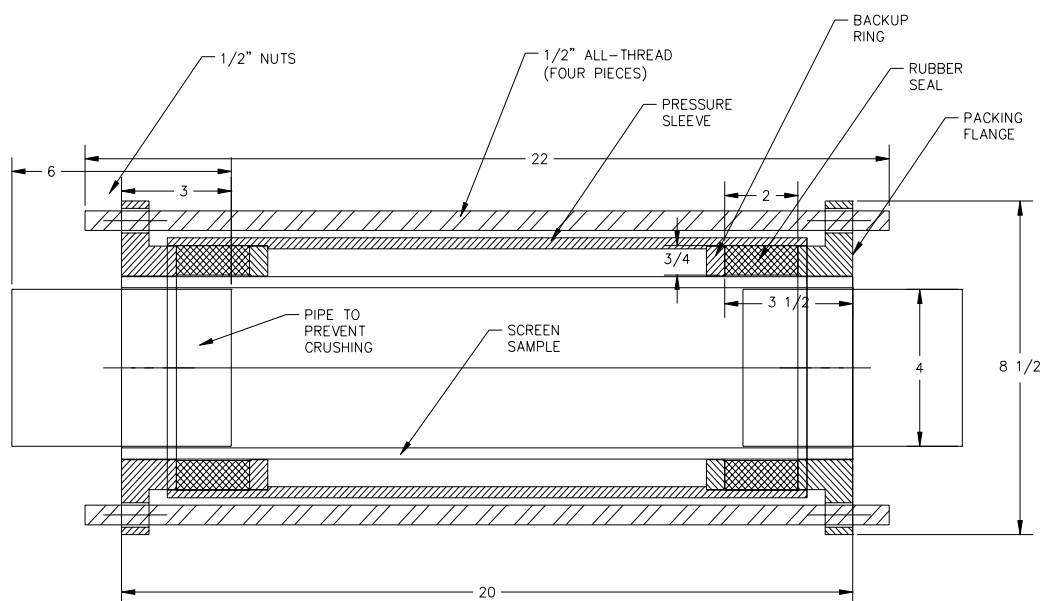
surpassed the elastic limits of the screen. The one test conducted on base pipe was a leak test created by  $\Delta p$  across the screen. This must be done on base pipe so the flow can be directed through the holes drilled in the base pipe.



### 3.0 TESTING

The procedure, test fixture, and results for each of the tests; collapse, tension, compression, torsion, and leak integrity, are documented in the following sections of the report.

Each screen sample was placed inside a pressure chamber constructed by Mohr to maintain an external pressure on the sample while measuring the distortion and external pressure through each of the mechanical tests. A diagram of the pressure chamber and one screen sample is shown below:



The chamber is sealed around the sample and a pump is connected to the chamber through a  $\frac{1}{2}$ " port. A pressure transducer is attached in the other port in the pressure sleeve.

### 3.1 Axial Tension Tests

The screen sample had 2-4" OD pipe pieces welded on to either end. The end pieces then had holes drilled through them to pin them into Mohr's 1-million

pound load frame. The 4" pipe did not run through the screen sample but was used merely for attachment to the 2" pins on the load frame. Load was then applied to the ends and the load and axial deflection were recorded. Initial tests were conducted while holding pressure of 200-220 psi through the pressure chamber on the outside of the screen to determine if a leak path were to occur prior to tensile failure.

### **3.1.1 Test Procedure**

The following is the test procedure followed for the Axial Tension Tests:

- Equip screen sample with pipe ends drilled with 2" diameter holes to pin to load frame.
- Place pressure sleeve around screen sample with plugging agent pump and pressure monitor connected.
- Secure sample cell in load frame using 2" diameter pins.
- Pressure sleeve to 200-220 psi around screen sample.
- Slowly increase axial tension and monitor load until sample fails.

Failure is designated as the point at which the sample no longer holds 200-220 psi external pressure or surpasses the elastic limit of the screen sample in tension.

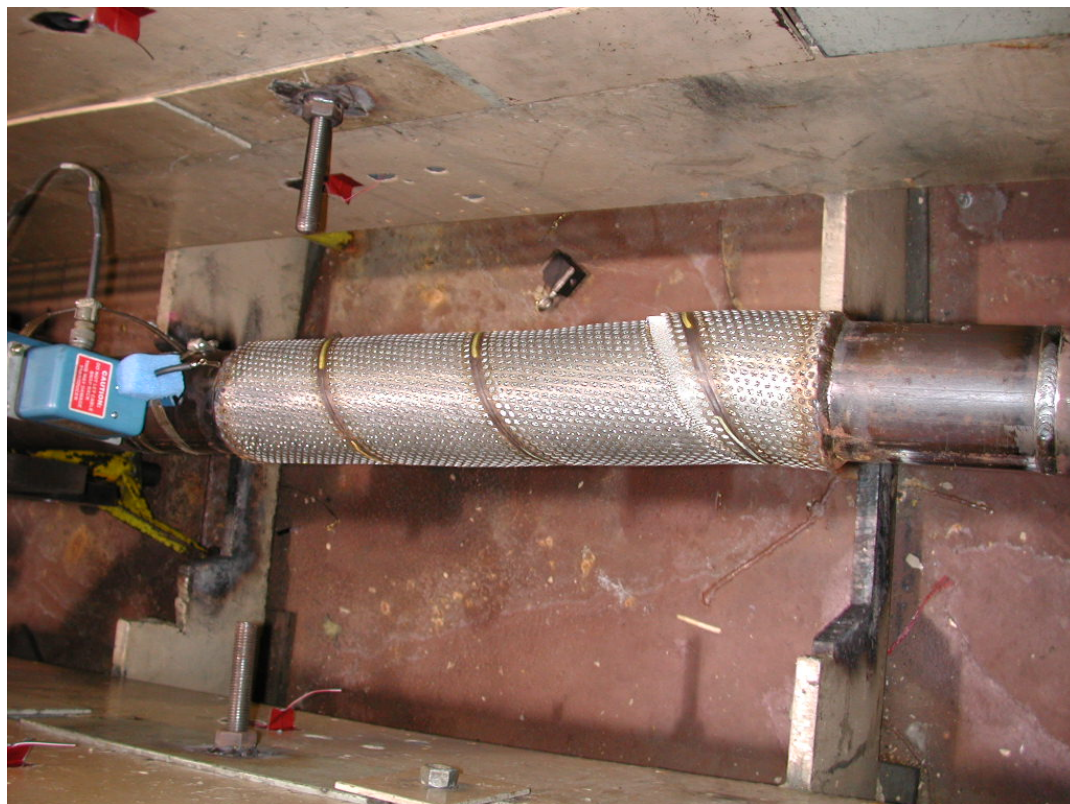
A picture of the test set-up is shown below:



### 3.1.2 Test Results

The load was continually increased on the screen until there was a tear in the outer shroud between the drilled holes in the shroud. The maximum tension measured prior to the failure in the sample was 58,647 lb-f. The sample stretched approximately 0.95 inches (4.75% of the length of the screen sample). This elongation in the screen sample is greater than the base pipe would stand. It was also noted that the sample did not leak even when the outer shroud actually gave away. This should offer encouragement to those companies running the TPM screens that the base pipe would actually fail in tension prior to the screen stretching to failure. Theoretically, this test would indicate that any pulling that was done during the installation would not interfere with the screen's ability to perform up to the actual failure of the base pipe itself.

A picture of the failed sample is shown in the following:



**NOTE: The failure is not a tear along the seam but in the drilled holes.**

### 3.2 Axial Compression Tests

The screen sample was again placed inside of the pressure sleeve with 200-220 psi external pressure added through the plugging agent pump. The sample length was a bit longer to provide a shoulder to press on axially with the calibrated Baldwin frame. The sample was placed between the faces of parallel platens to add compression load while maintaining external pump pressure. External pressure, load and axial deflection were measured while adding load to the sample until compression failure.

### 3.2.1 Test Procedure

The following is the procedure for the Axial Compression Test:

- Weld short pipe end sections into the screen sample to prevent the ends from buckling when the load was added.
- Insert sample section in pressure sleeve and connect plugging agent pump and pressure monitor.
- Place platens on each end of the sample to insure equal compression load on bottom and top of screen sample.
- Pressurize sleeve to 200-220 psi using plugging agent pump.
- Slowly apply load using Baldwin load frame until a leak path occurs or the screen sample reaches elastic limit in compression.

A picture of the test set-up follows:



### 3.2.2 Test Results

Compression load was added until the screen sample failed at the very end of the sample at 45,469 lb-f where it came in contact with the top platen. The total compression was 0.272" or 1.13% of the sample length. The sample never developed a leak path during the test. When we determined the failure was on the outer shroud on the end of the sample (see picture), the recommendation was made to collapse the sample by pumping on the plugging agent pump. We continued to pressure up on the sample until there was no further deflection on the screen.



#### Top end failure in compression

The collapse phenomenon was quite interesting as the internal shroud collapsed in three places around the circumference in the screen but all at the same distance from the end of the screen. It appears that the first collapse as noted on

the earlier test tends to weaken the inner shroud on the same level and multiple failures occur in the same area of the screen up to 3 collapse areas as shown in the following picture:



**Ultimate collapse after compression test**

### **3.3 Torsion Tests**

The screen sample was again fitted in the pressure sleeve to insure that a leak path did not occur during the torque testing of the sample. Two 4" OD pipes were welded to the ends of the screen sample to be placed in the C&H bucking machine so that torque could be applied to the sample. The plugging agent pump applied external pressure of 200-220 psi while the torque was increased on the screen sample. External pressure, torque load, and rotation (degrees from initial position) were measured.

### 3.3.1 Test Procedure

The following procedure was followed in the Torsion Tests:

- Weld 4" OD end subs on screen sample for gripping in C&H's bucking machine.
- Fit pressure sleeve over screen sample and connect plugging agent pump and external pressure monitor to the fixture.
- Insert test fixture into the bucking machine.
- Hook up Mohr's 20,000 lb load cell on C&H's four-foot moment arm to calculate torque.
- Install extensometer to outside of sample to calculate rotation on the sample.
- Pressure up the sleeve to 200-220 psi external pressure.
- Slowly add rotation through the bucking machine until a leak path develops in the sample or the torque elastic limit is reached. Two samples to be turned clockwise (expanding wrap on outer shroud) and two to be turned counter-clockwise (contracting the wrap on the outer shroud).

A picture of the test set-up is shown in the following:





### 3.3.2 Test Results

C&H gradually increased the torque until the inner shroud began to deform in a twisting configuration. When the screen reached its elastic limit the torque dropped sharply. The samples that were torqued clockwise were consistent in their maximum torque values at 4,066 ft-lbs (10.3° rotation) and 4,096 ft-lbs (10.4° rotation), respectively while the samples that were torqued counter-clockwise were somewhat inconsistent in their maximum torque values at 3,740 ft-lbs (11.5° rotation) and 4,566 ft-lbs (10.6° rotation). No internal leak path occurred during the test until after the inner shroud failed and then maximum collapse was sought by increasing pump pressure until the inner shroud collapsed on itself. While the screen will again be stronger attached to base pipe and will resist more torque it should be noted that the screen will take pulling and pushing better than rotation. The screen is robust and will stand up to some rough treatment in the installation of the screen and will still maintain its resistance to leak paths.

The following picture shows the failure of the screens in torque tests:



---

This sample was torqued to 227° or 3/4 of a turn to total destruction without internal leak path developing.

### 3.4 Collapse Tests with Simulated Perforated Base Pipe

TPM made a 12" long section of 4" OD base pipe with four ports in it. This was to simulate a base pipe so that collapse could be measured in the screen on top of the base pipe. The four ports were 3/4", 5/8", 1/2", and 3/8" in diameter and were vented out through one central end port. A 6" length of screen was welded over the base pipe and then the sample was placed in a 20-ksi-pressure vessel. The central vent port was connected to the vessel head so that external pressure could be applied to the sample to create erosion through the base pipe holes. To fail, the three layers of mesh and the inner shroud would have to fail under external pressure.

#### 3.4.1 Test Procedure

The following procedure was used in the Collapse Tests Simulated with Perforated Base Pipe:

- Make a 4" OD base pipe 12" in length and drill four ports in the pipe in the diameter of 3/4", 5/8", 1/2", and 3/8".
- Weld screen sample over top of base pipe with central end port in one of the end plates.
- Place sample in 20-ksi-pressure vessel.
- Install pressure monitor to measure pressure exerted externally on screen.
- Apply external pressure to screen to attempt to create collapse or erosion in screen.

The following picture is the set-up for this test:



### 3.4.2 Test Results

Mohr applied pressure with a large capacity pump until an internal leak path was established. The test reached a maximum of 7,504 psi. It is suspected that at this level of pressure and at this late stage of testing, the plugging agent had broken down sufficiently that it would not stand the high differential pressure.

Inspection of the screen showed no enlarged holes in the fine mesh although it had deflected 0.15" at the 3/4" port center. It is believed by all of the witnesses that the screen was capable of holding more pressure as no real damage had occurred to any of the components of the screen.

The following picture reflects the good shape the screen was still in after testing.



---

## 4.0 WIRE MESH INFORMATION

The following information was supplied to TPM from Dorstener Wire regarding two different meshes being used in the TPM screens:

### **24 X 110 Mesh (0.015"/0.01") – Filtration**

Warp Count: 24  
Shute Count: 110  
Warp Wire Diameter: 0.015"  
Shute Wire Diameter: 0.01"  
Type of Weave: Plain Dutch

Geometric Percent of Porosity: 59%  
Nominal Micron Rating: 80  
Absolute Micron Rating: 115-125  
Nominal Opening: 0.00315"

Flow Rate:  
Motor Oil: 3.5 GPM/Sq. inch  
Fuel Oil: 7.9 GPM/Sq. inch

### **10 X 10 Mesh (0.025") – Drainage and Stand Off**

Warp Count: 10  
Shute Count: 10  
Warp Wire Diameter: 0.025"  
Shute Wire Diameter: 0.025"  
Type of Weave: Plain

Geometric Percent of Porosity: 56.3%  
Nominal Micron Rating: 1908  
Nominal Opening: 0.075"