

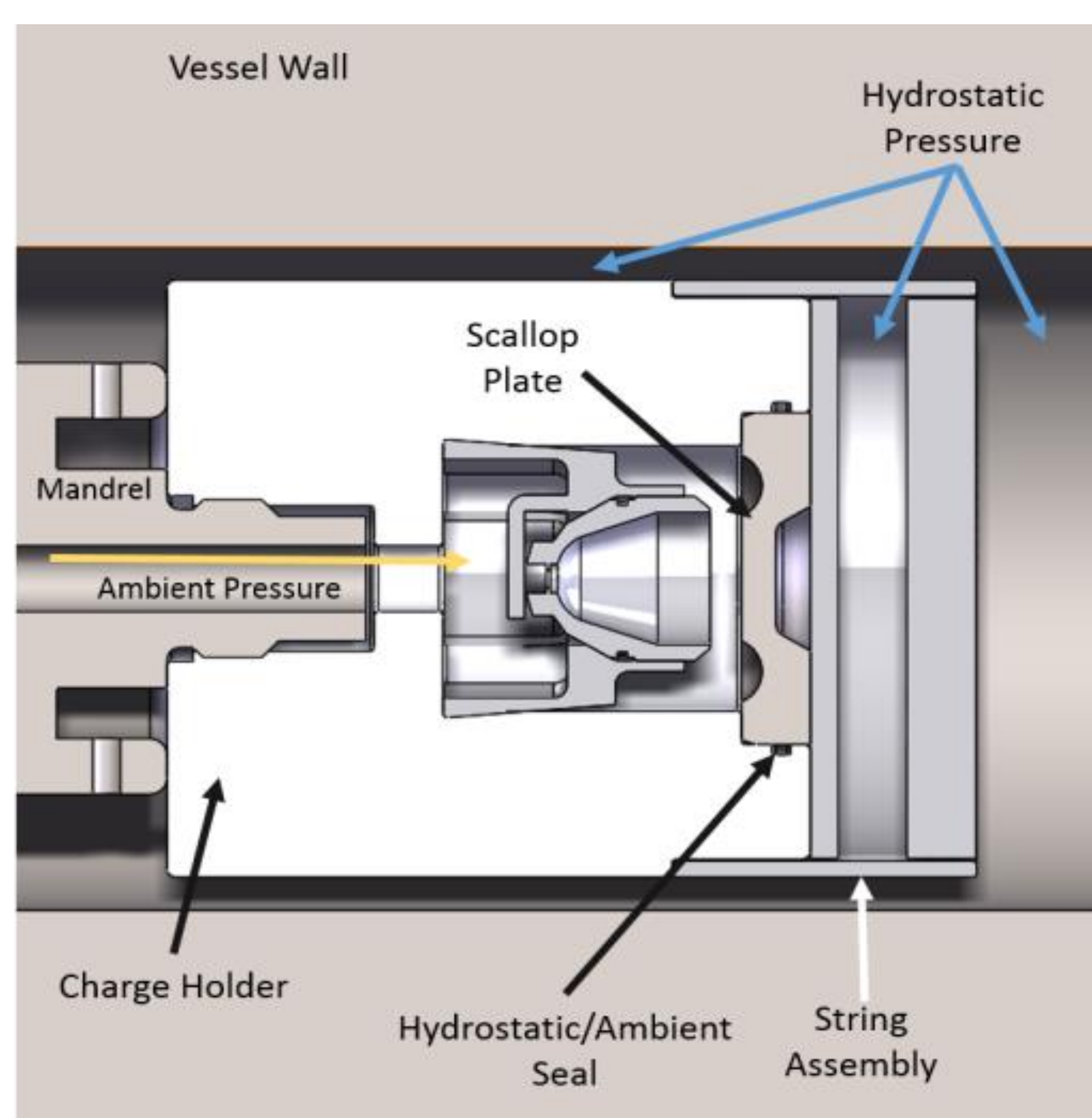
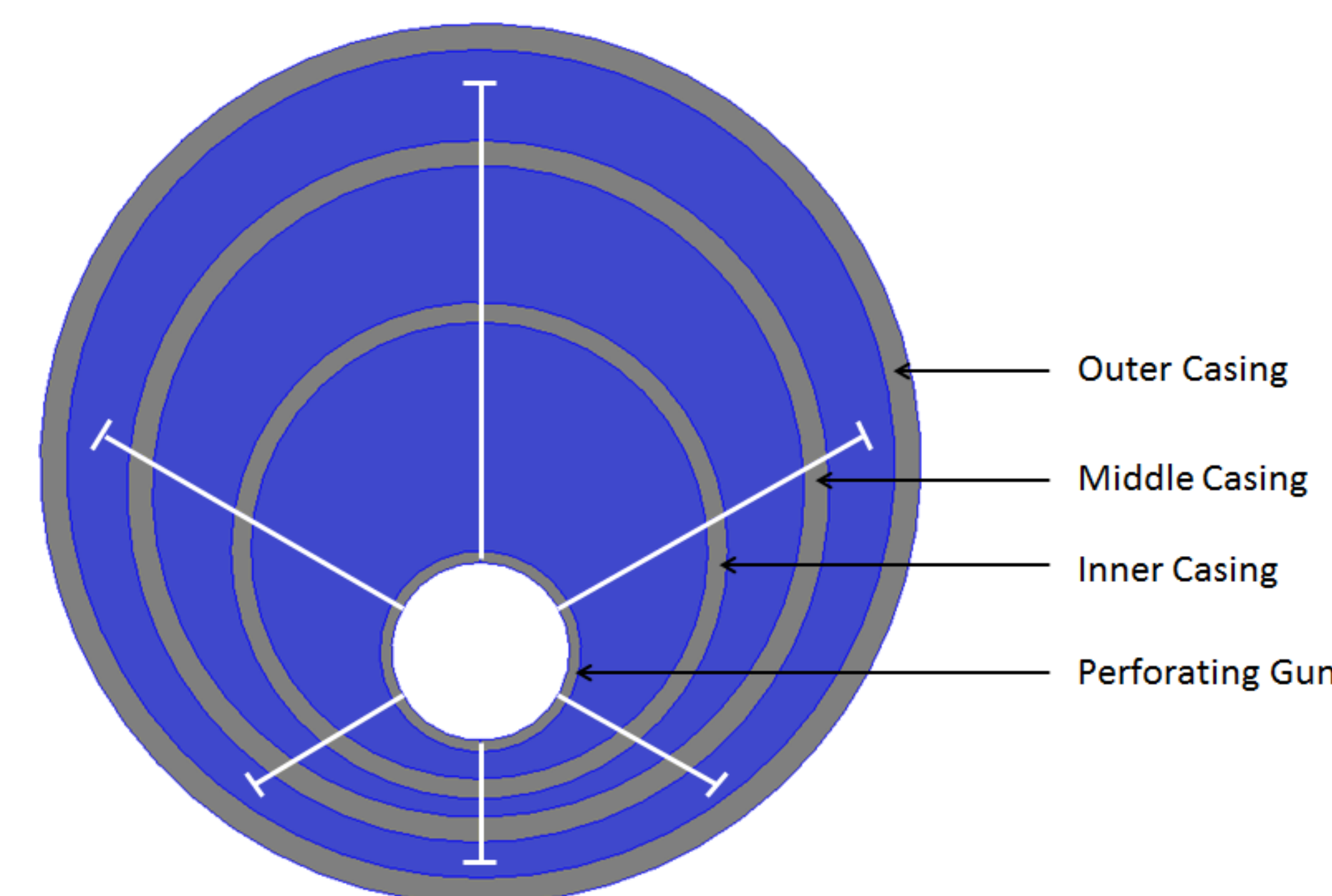


Effects of Hydrostatic Pressure on Limited Penetration Perforating Systems

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Background:

In Oil & Gas wells there is often a need to perforate in order to achieve circulation in the well. In these unique instances there is a desire to perforate the innermost string(s) without damaging the outmost production casing. Historically these systems are tested and qualified under ambient conditions with a specific amount of allowable damage.



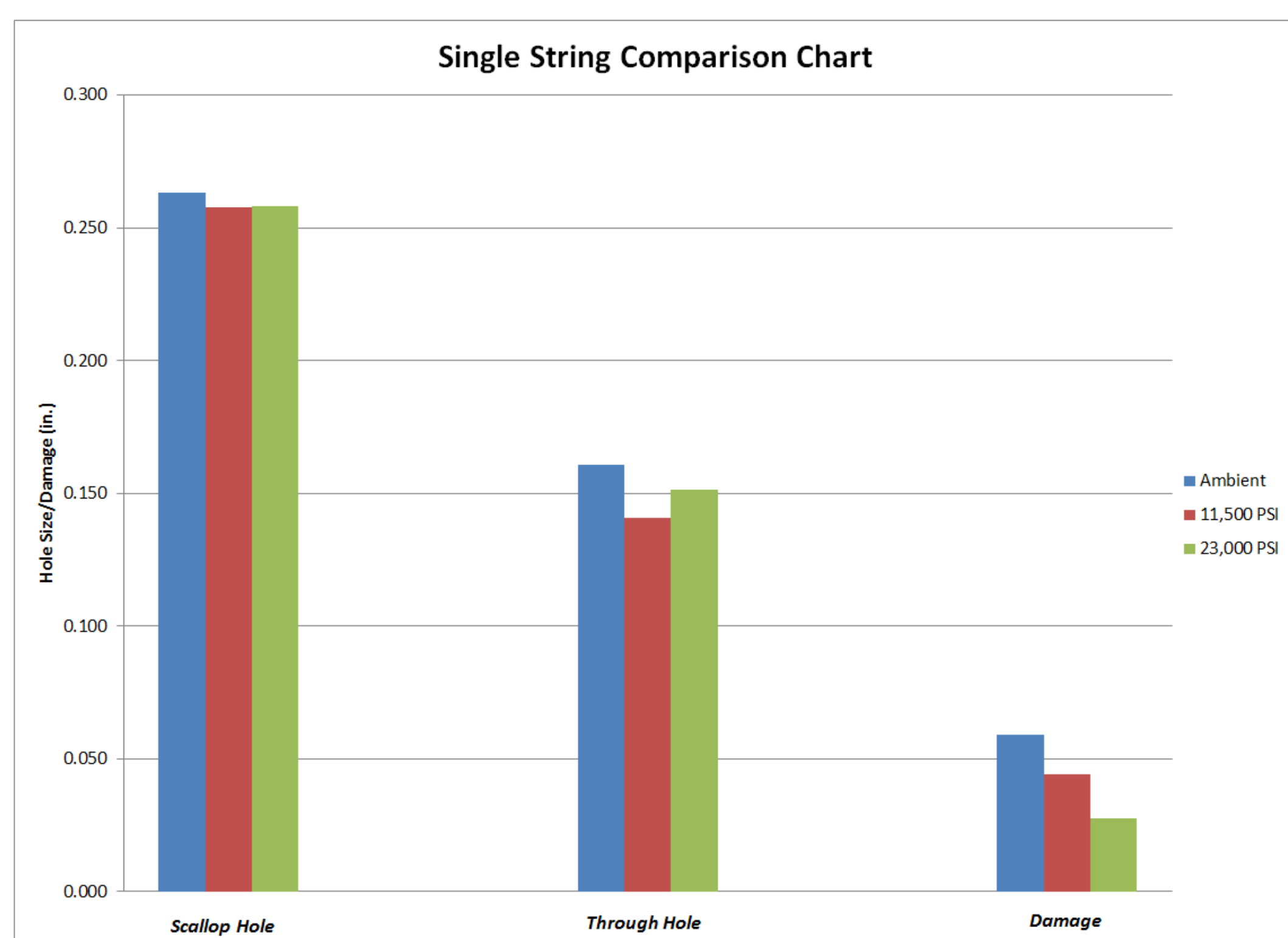
Test Apparatus and Setup:

A custom designed test vessel setup was built in order to test circulation perforating charges while placing the simulated wellbore under hydrostatic pressure. This allowed for hydrostatic pressure to be distributed equally between all casing strings being tested.

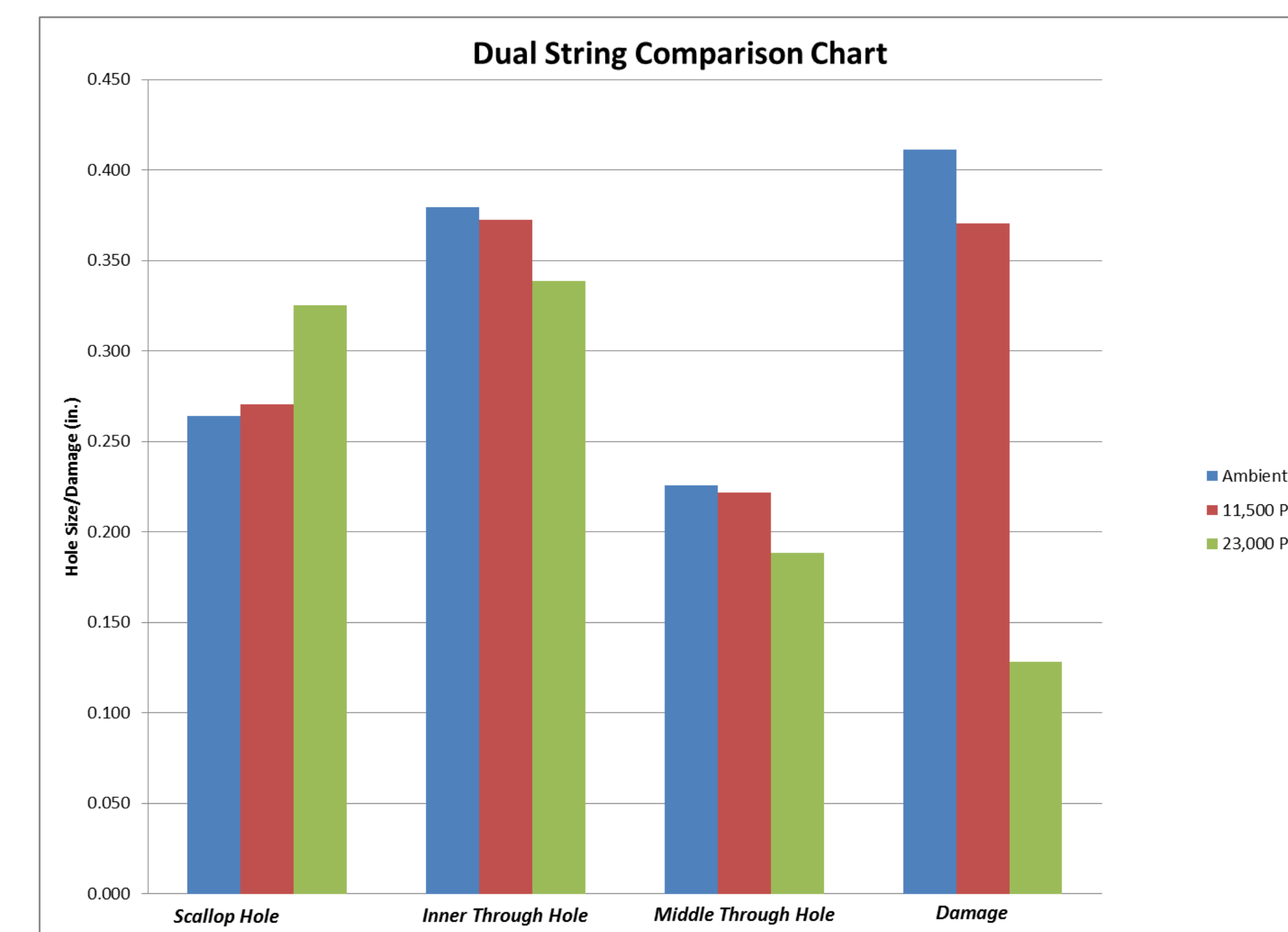
Test Method and Results:

For each of the pressure level scenarios being examined 3 test shots were conducted at each and the average performance was reported.

The flow area was measured by flowing water through the perforated plate and measuring the velocity in order to calculate the true flow area.



Test Condition	Single String, in ²	Dual String, in ²	
		Inner Casing	Middle Casing
Ambient	0.022	0.113	0.040
11,500 psi	0.017	0.109	0.039
23,000 psi	0.028	0.062	0.018



Single String Performance Results			
Test Condition	Gun Scallop Hole avg, in.	Casing Through Hole avg, in.	Witness Damage, in.
Ambient	0.263	0.161	0.059
11,500 psi	0.258	0.141	0.044
23,000 psi	0.258	0.151	0.028

Dual String Performance Results				
Test Condition	Gun Scallop Hole avg, in.	Inner Casing Through Hole avg, in.	Middle Casing Through Hole avg, in.	Witness Casing Damage, in.
Ambient	0.264	0.379	0.226	0.411
11,500 psi	0.271	0.372	0.222	0.370
23,000 psi	0.325	0.339	0.188	0.128

Conclusions:

- For the single string scenario, the total reduction in damage from ambient to 23,000psi was 52.5%
- For the dual string scenario, the total reduction in damage from ambient to 23,000psi was 68.9%
- The hole size drop in the primary casing string for both scenarios ranged from 12.4% to 15.3%

In limited penetration scenarios where elevated hydrostatic pressure is present, customers can expect reductions in penetration depths, or casing damage, and through hole averages.