HPHT Perforating Practices - IPS-12-14

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HALLIBURTON

How We Define HP/HT

IPS-12-14

Worldwide HP/HT Areas

Operator's Challenge to the Service Industry

Develop new perforating processes and tools with higher temperatures and pressure capabilities.

- How do we safely and effectively perforate HPHT wells?
  - **Health, Safety and Environment** are first on the list
  - Study the project to **identify and understand** all challenges
  - Software **simulations and lab** tests to ensure it is feasible.
  - Resource selection (Personnel, explosives and hardware)

Keep this in mind

- Hardware (steel) is rarely affected by temperature or well bore completion and drilling fluids but they are affected by pressure.
- Explosives are not affected by pressure or wellbore fluids but are affected by temperature.
- Elastomers are the one item that can be affected by all three of these variables – temperature, pressure and fluid type.

Identify/Understand the Challenges

Challenges

- Effects of high temperature on explosives and elastomers
- Combined loading and pressure differential
- Limitations in metallurgy selection
- Design constraints due to high-pressure effects (OD / ID)
- Sealing technologies (dynamic and static)
- Economically viable solution

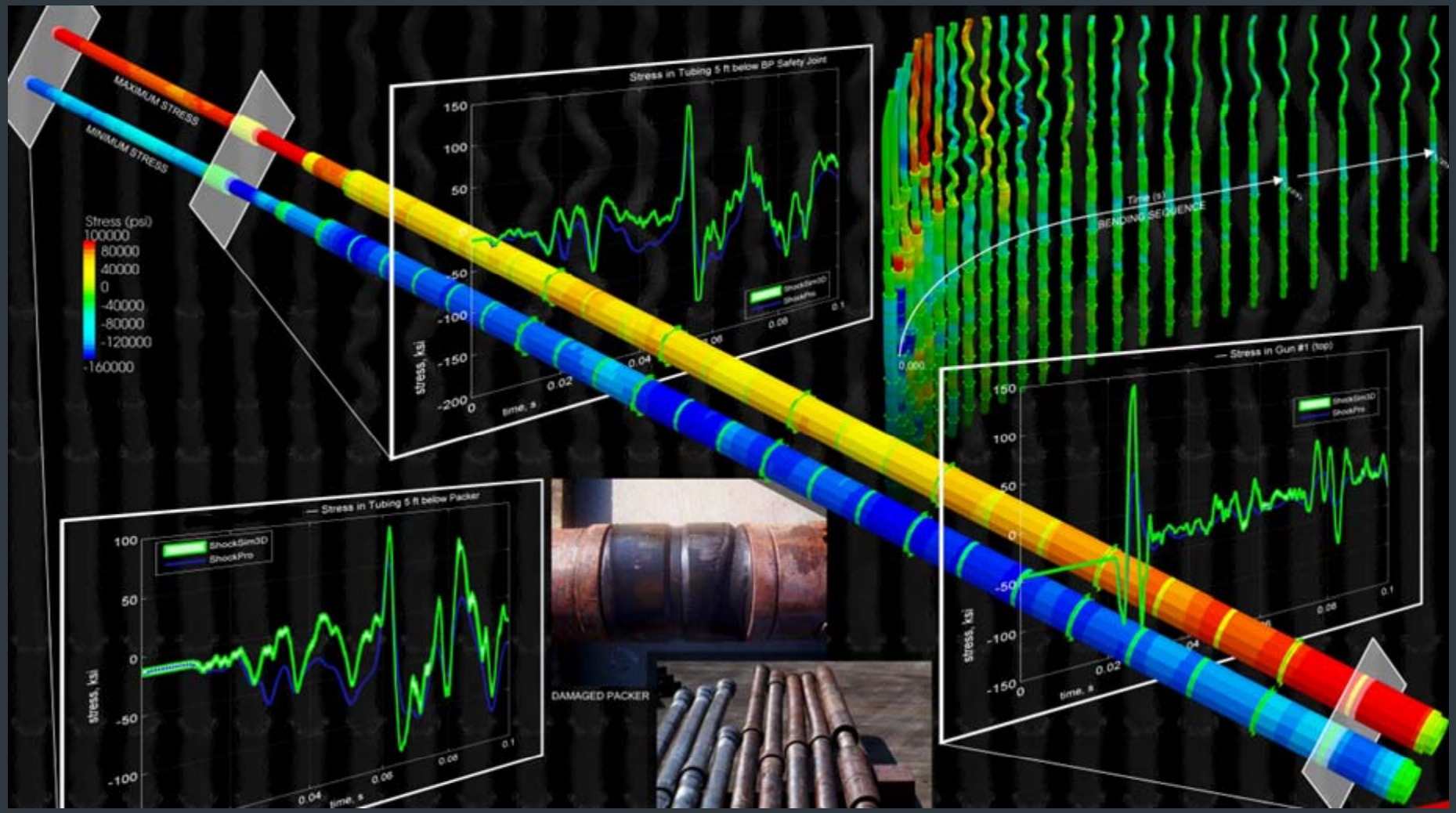
Engineering Capabilities

There are significant challenges with a number of technologies in providing higher levels of HPHT performance and reliability (e.g. electronics, materials, explosives, etc.)

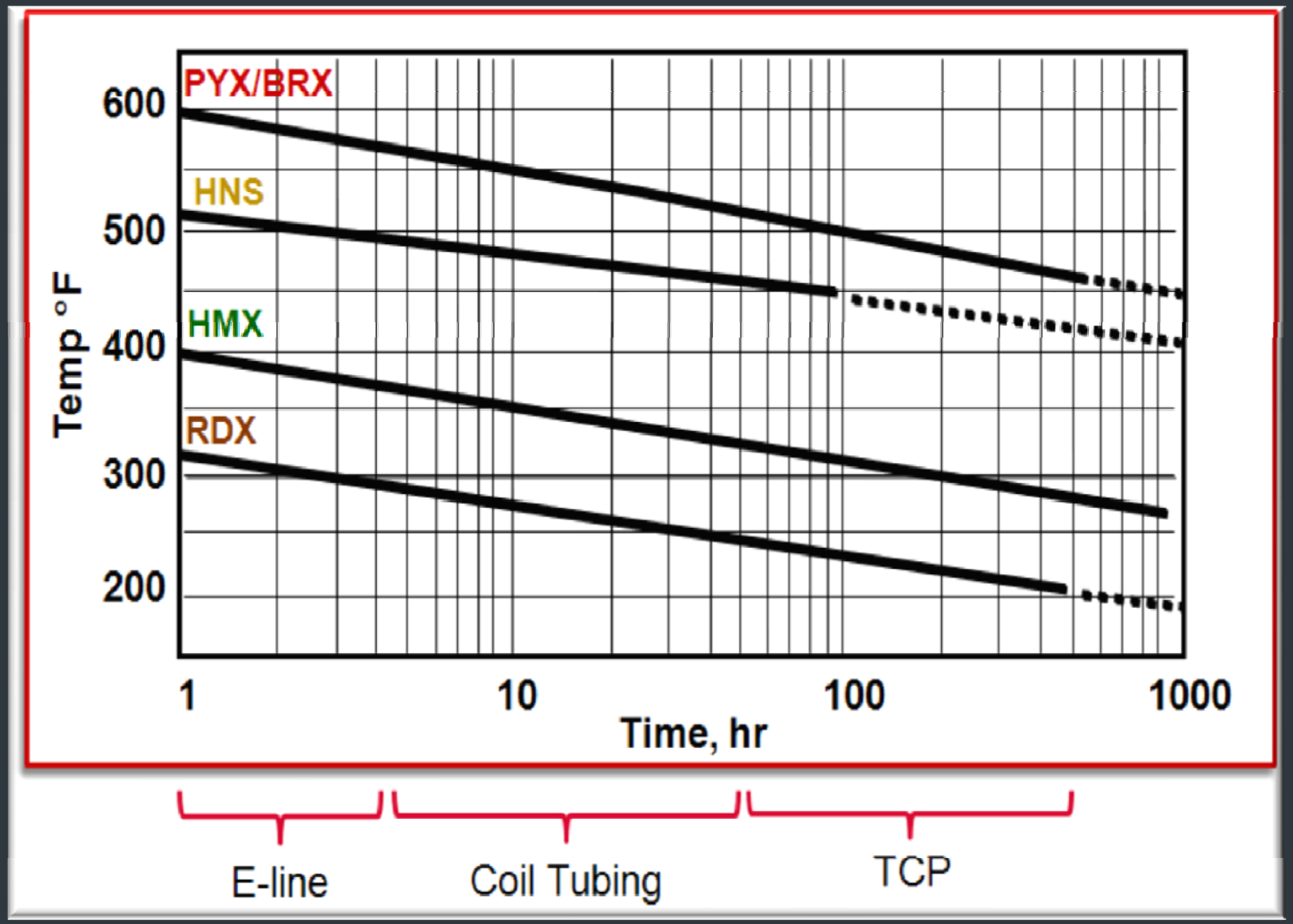
Testing

Systems integration testing is critical
Testing facilities to handle the extreme temperatures (500°F) and Pressures (40000psi +)

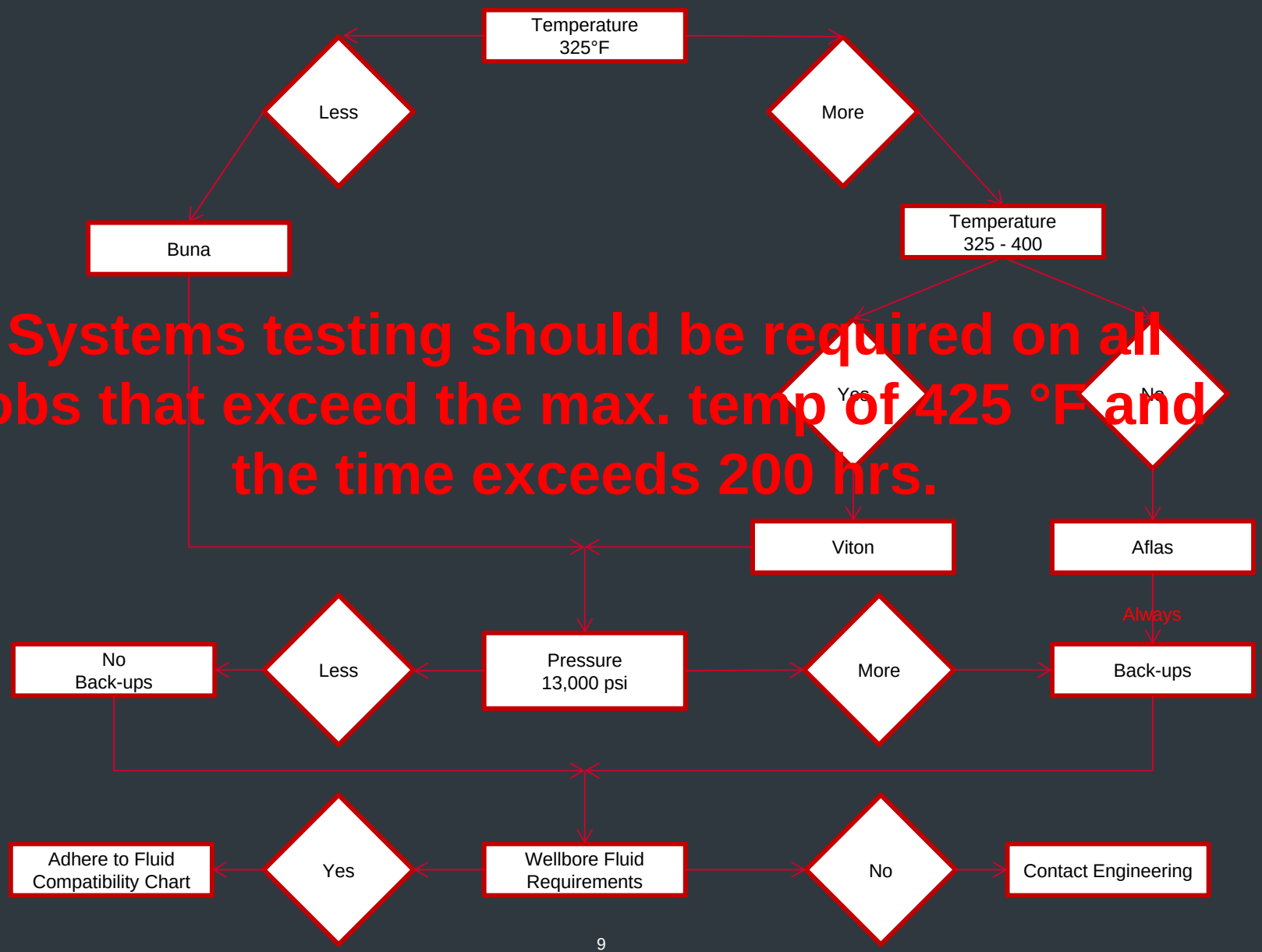
Job Simulation



High Temperature Explosives and Conveyance Method



Steps to be followed to setup HPHT Services



Systems testing should be required on all jobs that exceed the max. temp of 425 °F and the time exceeds 200 hrs.

Elastomer Selection

	ASTM D1418 Designation	NBR - Peroxide Cure	FKM	FKM	FEPM
	Trade Name	Nitrile	Viton®	Fluorel®	Aflas®
	Specification	599.33001	600.33001	600.33001	601.30000
	Min. Temp. °F (°C)	-40 (-40)	-10 (-23)	-10 (-23)	40 (4)[3]
	Max. Temp. °F (°C) Exposure ? 24 hours	400 (204)	500 (260)	500 (260)	500 (260)
	Max. Temp. °F (°C) Exposure ? 5 days	350 (177)[4]	400 (204)[5]	400 (204)[5]	400 (204)
	Max. Temp. °F (°C)	275 (135)	325 (163	325 (163	400 (204)
	Max. Pressure at 500°F		10,000 psi (68,940 kPa)[6]	10,000 psi (68,940 kPa)[6]	10,000 psi (68,940 kPa)[6]
	Max. Pressure at 350°F	10,000 psi (68,940 kPa)	10,000 psi (68,940 kPa)	10,000 psi (68,940 kPa)	10,000 psi (68,940 kPa)
	Max. Pressure at 275°F	15,000 psi (103,410 kPa)	10,000 psi (68,940 kPa)	10,000 psi (68,940 kPa)	8,000 psi (55,152 kPa)
	Max. Pressure at 150°F	20,000 psi (137,880 kPa)	15,000 psi (103,410 kPa)	15,000 psi (103,410 kPa)	8,000 psi (55,152 kPa)
Gases	H_2S		8	8	8
	CO_2	8	8	8	8
	CH_4 (Methane)	8	8	8	8
	N_2	8	8	8	8
Oil Base Fluids	Sweet Crude				
	Diesel				
	Aromatic hydrocarbons & Solvents (Xylene	7			7
	Oil - Based Muds / Fluids	9	9	9	9
	Ester-based drilling mud				
	Amine / Oil Inhibitors	7			
Water Base Fluids	Water based inhibitors				
	Steam				
	Salt Water				
	Zn Bromide				
	Ca Bromide (<14.2 ppg)				
	Na Bromide (<12.4 ppg)				
	Formates				
	High pH fluids (>9)				
Other Fluids	Alcohols				
	Methanol				
	HCl & HF Acid Mixture				
	Weak Acid (HCL<15%)				
	Strong Acid (HCL>15%)	7			
	Acetic & Formic Acids				

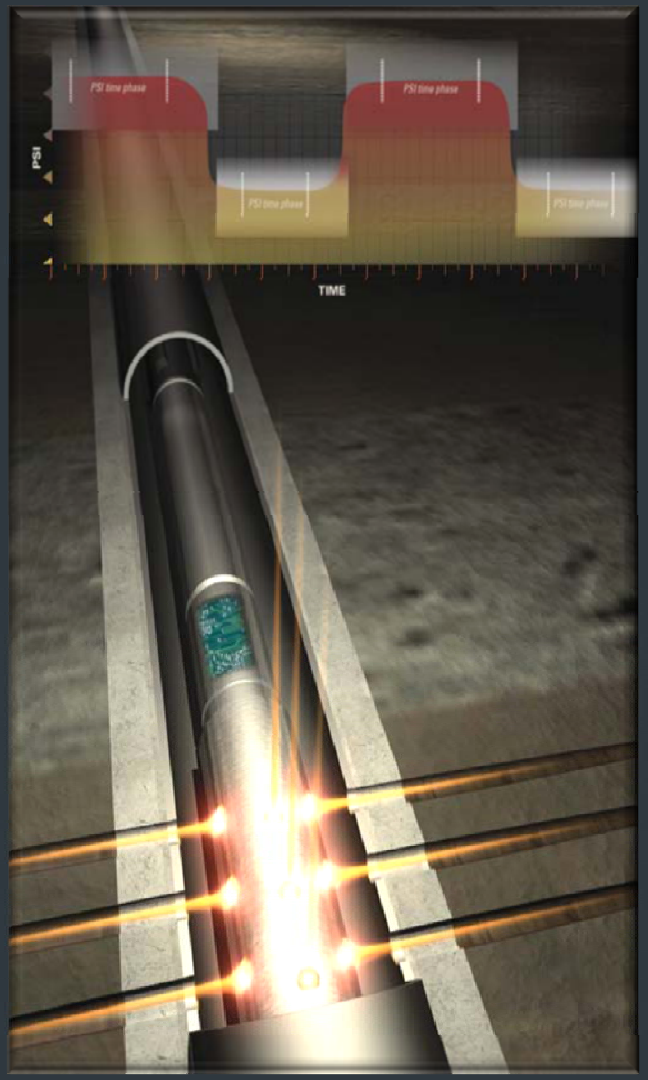
- Excellent - Recommended
- Good - Slightly affected, but no significant
- Conditional - Time and/or temperature
- Conditional - Operation considerations for
- Not recommended
- No information available

Notes

1 Use Virgin PEEK backup rings above 400\F (204\C) and 10,000 psi (68,940 kPa).
2 Use Virgin PEEK backup rings above 350\F (177\C) and 5,000 psi (34,470 kPa).
3 Minimum temperature is 100\F (38\C) if backup rings are used. The minimum temperature is 40\F (4\C) if backup rings are not being used.
4 Field reports have shown successful results of working at 350\F (190\C) for 15 days.
5 Field reports have shown successful results of working at 410\F (210\C) for 8 days.
6 Virgin PEEK backup rings (beige) are rated to 10,000 psi (68,940 kPa) at 550\F (288\C). Pink 25% glass Teflon backups are rated to 10,000 psi (68,940 kPa) at 400\F (204\C).
7 Physical degradation could occur.
8 Explosive decompression is compound dependent and could damage seals or elements. Consult Elastomer Best Practices for ED Resistant compounds.
9. Testing is recommended due to variability of proprietary ingredients of oil based muds

Hardware Requirements

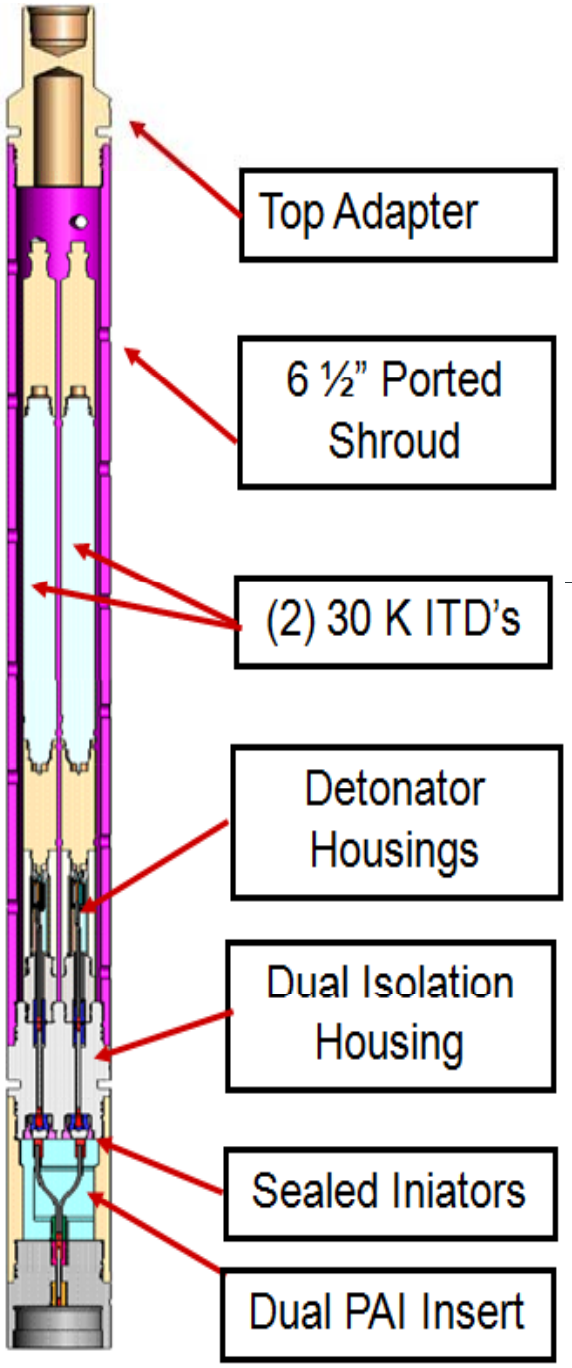
- Ultra High Pressure Perforating Gun
- FH's capable of low pressure cycle
- Immediate or delayed detonation
- Operate in ultra high pressure
- Prevent damage to lower rated tools
- Helps reduce rig time and costs
- Completion procedure flexibility
- Rated up to 30,000 psi



Shrouded High Pressure Electronic Dual FH System

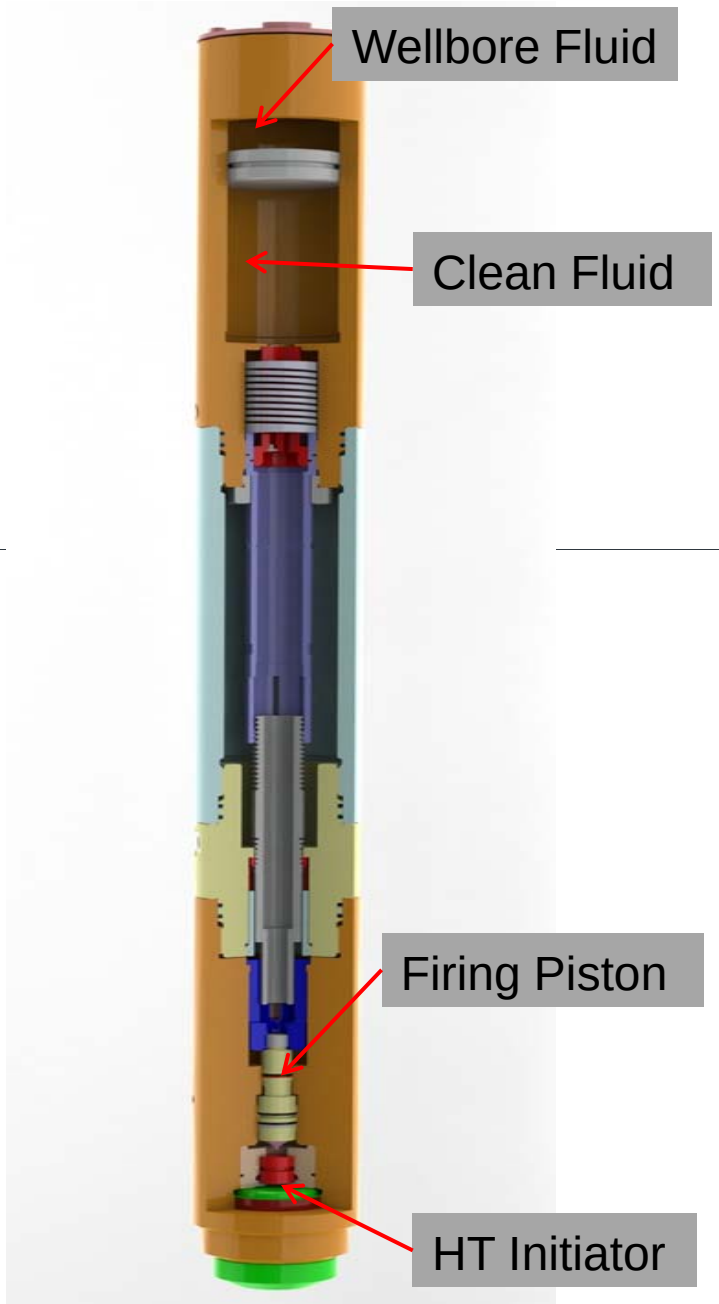
Dual low pressure cycle Intelligent Trigger Devices in a shroud that would make the connection between landing string and the gun assembly, thus eliminating the tensile and compression loads from the firing heads.

- Shut down/restart
- 30Kpsi rated
- 315°F
- Up to 36 hr. delay



MultiCycle Firing System

- 4 - 10 low pressure cycles to activate
- Function and test other tools prior to firing gun system
- Fires on bleed off – Optional Delay
- 30Kpsi rated
- No electronics

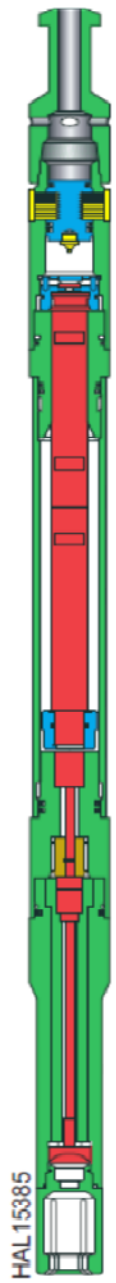


Absolute Pressure

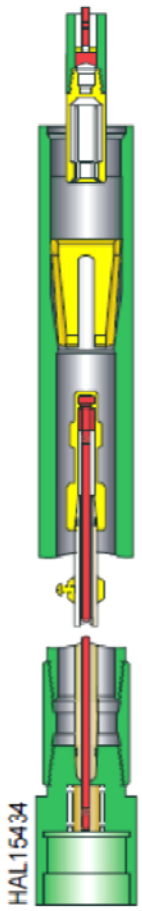
- Installed bottom or top of gun assembly
- 425°F for 200hrs.
- 30Kpsi rated
- Deployable with other firing devices

Wireline Deployed

- Deploy guns w/o the FH
- Deploy firing head after pressure testing and displacing heavier fluids.
- FH less exposure to high temperature
- Rated for 425°F for 200hrs.
- Rated for 27Kpsi
- Retrieve and replace without having to pull guns



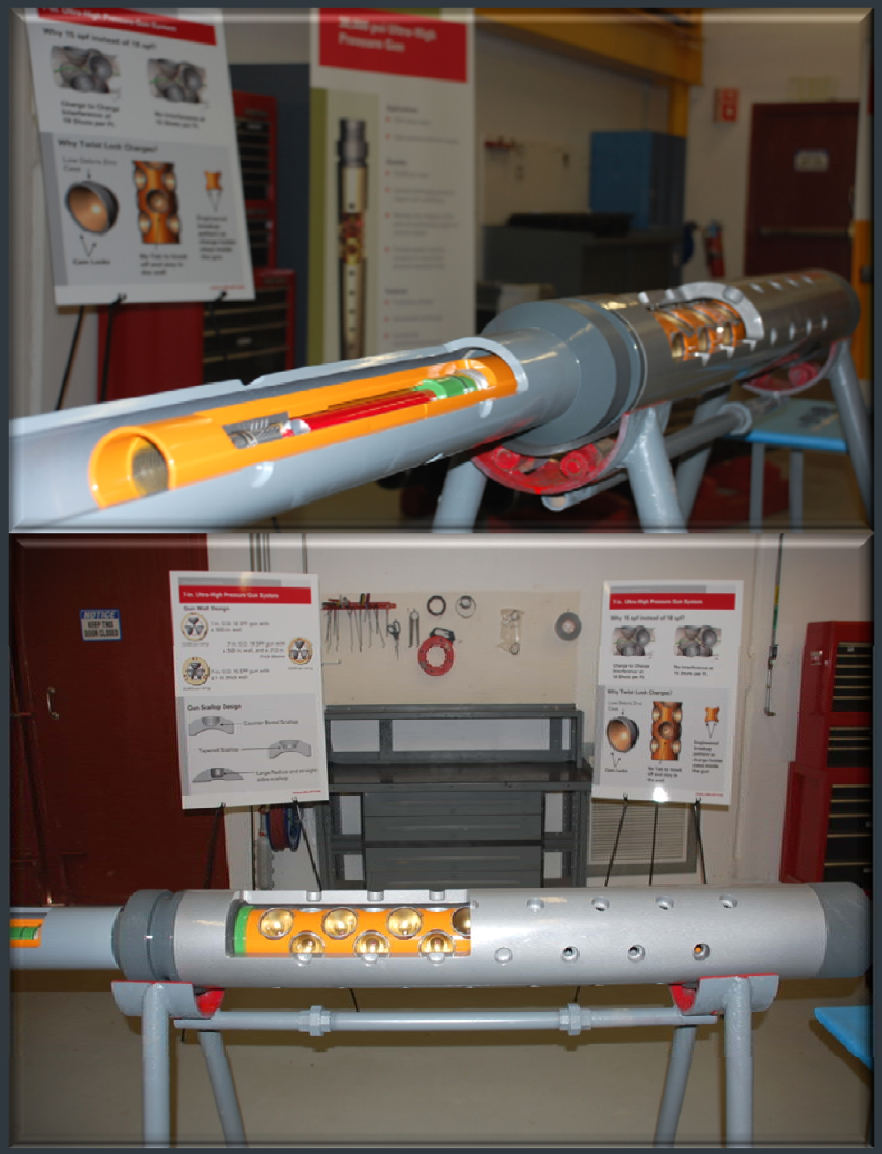
Slickline Retrievable Time-Delay Firer (TDF) Firing Head



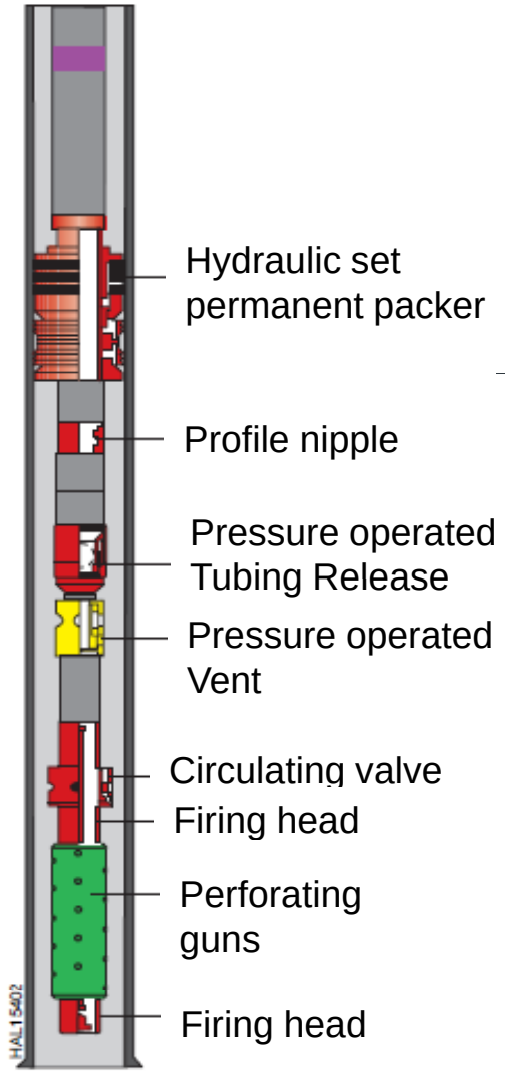
Stinger Assembly

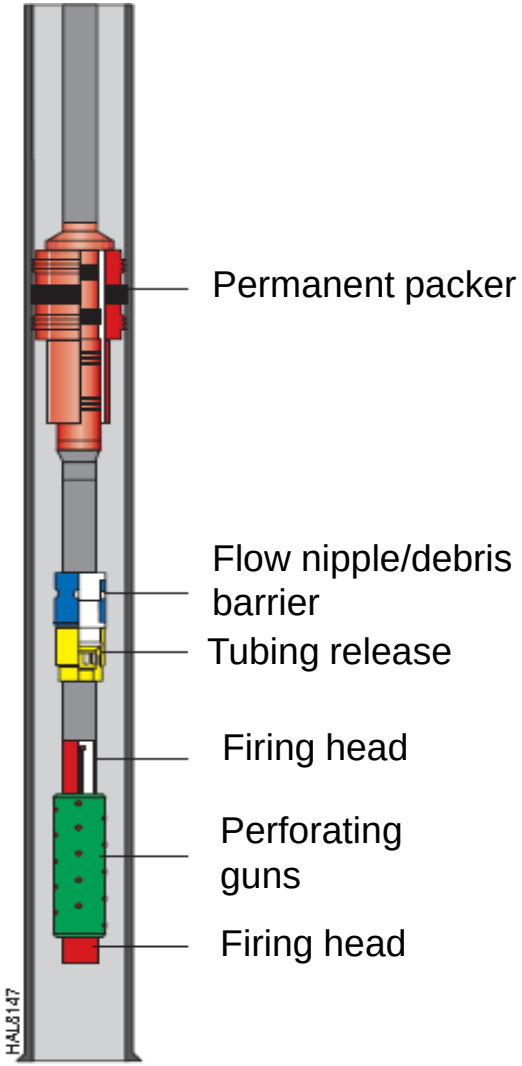
High Pressure Gun Systems

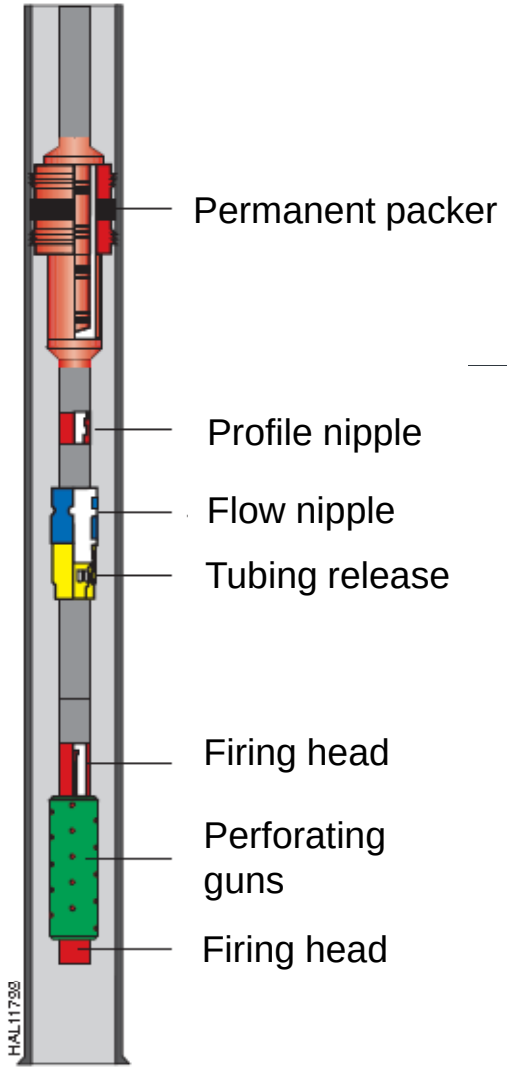
- 30Kpsi rated
- Special metallurgy – internal and external
- Shrouded firing head



Permanent Packer Installations







Case History: Mexico

CASE STUDY

CHALLENGE:
Perforate and DST a high temperature/high pressure gas well in 5 days.
Temperature – 320F
Pressure – 15093psi
Top Shot – 21522ft

SOLUTION:
Perforating Guns – Deploy 262ft of 3-3/8" 6spf guns loaded with HNS charges.
Firing head – Mechanical and hydraulic delayed as backup
Packer – Retrievable

RESULT:
The well was successfully tested and completed within the required time frame of 5 days.

Case History: North Sea

CASE STUDY

CHALLENGE:
Perforate a high temperature/high pressure gas well.
Temperature – 400F
Pressure – 16737psi

SOLUTION:
Perforating Guns – Deploy 2 ¾" 6spf guns loaded with HNS charges on Coiled Tubing
Firing head – Pressure actuated
Packer – Permanent
Depth Control – Memory GR/CCL

RESULT:
Successfully deployed gun through tubing, placed guns on depth and fired with no major issues.

Case History: GOM

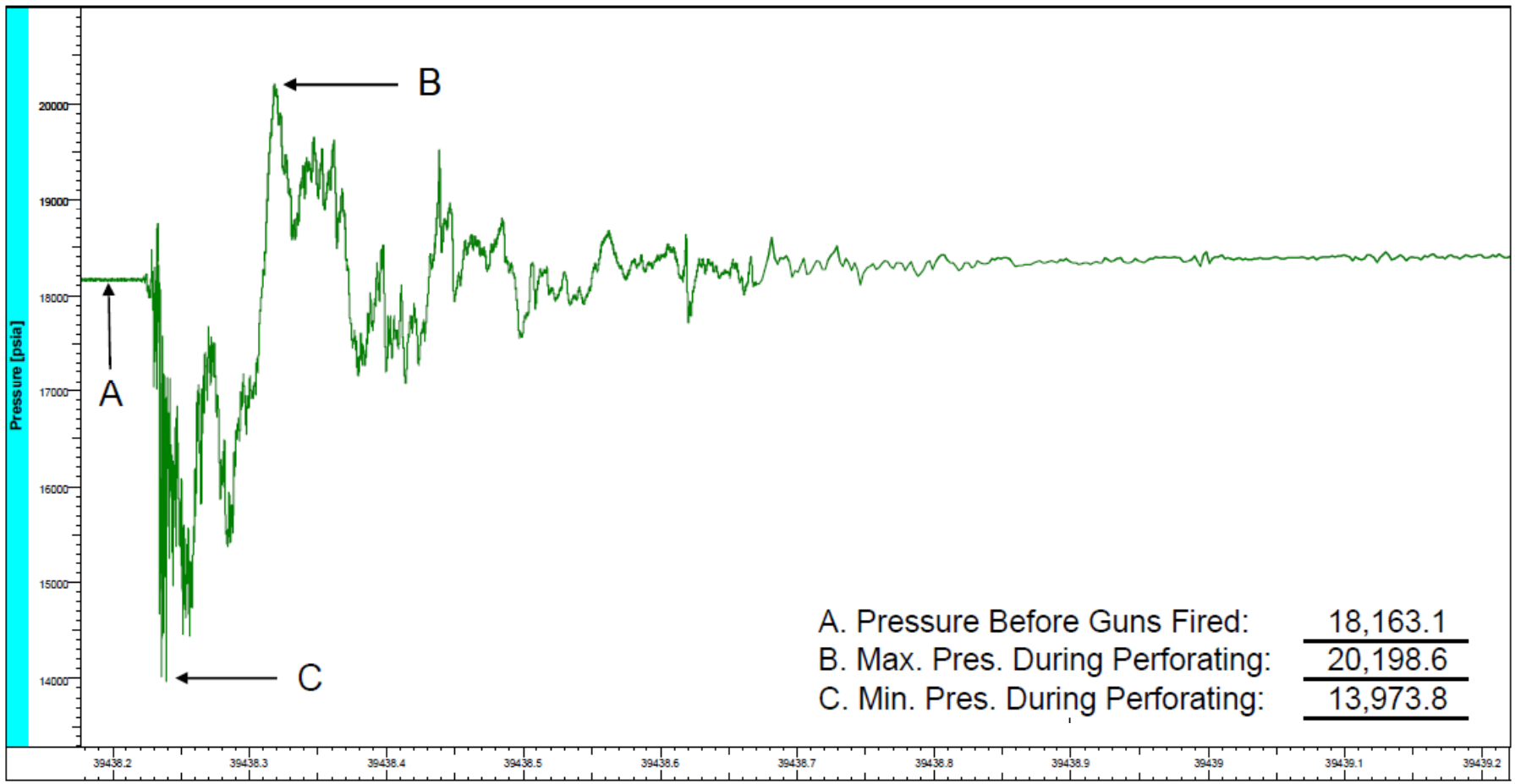
CASE STUDY

CHALLENGE:
Perforate shoot and pull a high pressure gas well without unsetting packer or damaging work string. Fast gauge recording is also required.
Water depth – 4468ft
TVD – 24500ft
Temperature – 183F
Pressure – 18670psi

SOLUTION:
Perforating Guns – Deploy 154ft of 6 1/2” 14spf guns loaded with RDX low debris (Mirage) charges.
Firing head – Dual Intelligent Trigger Devices
Packer – Retrievable
Data Recorder – Fast Gauge (115000 dps)

RESULT:
Job was successfully executed and data recorders captured the event.

Case History: GOM



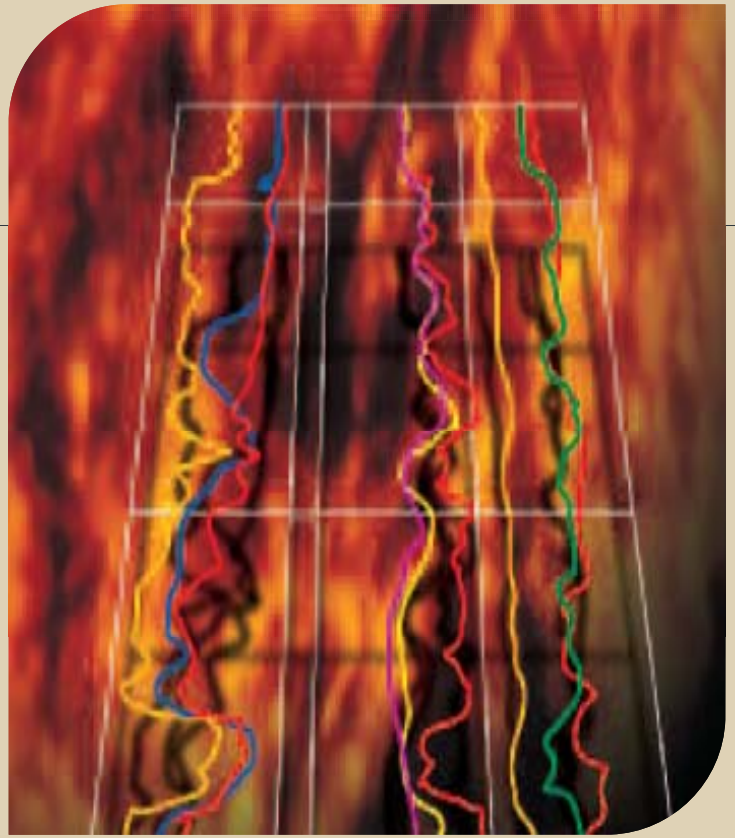
Case History: Malaysia

CASE STUDY

CHALLENGE:
Successfully perforate and test this high temperature well. Utilizing a 2500psi underbalance
Temperature – 392F
Pressure – 9450psi

SOLUTION:
Perforating Guns - 4 5/8” 12spf guns loaded with HNS charges
Firing head – TDF bottom and top
Packer - Permanent

RESULT:
The well was successfully tested and completed.




Modeling
Candidate Well Identified
Capability
Reliable Solution
Operational Excellence

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