

Agenda

- What is the M&W APRS?
- Background
- Proven Field Experience
- What are the benefits?
- Quality Assurance and Certificates

What is the M&W APRS?



An alternative annulus pressure relief system developed for well stimulation treatments and interventions based on burst disc technology



Invented to ensure higher accuracy and safety



Has shown higher reliability than other pressure relief systems (spring loaded valves and N₂ operated valves) which from time to time prove unreliable and cause premature job abortions



Used by several E&P and oil service companies on 1,000+ well stimulation jobs around the world for 25+ years



Can be used onshore and offshore



APRS Ready Box



Ruptured burst disc after use



Background

- It is standard procedure to protect casing annuli during well stimulation/intervention with two independent pressure protection systems:
 - Primary pressure protection is the electronic kick-out on the well stimulation pumps supplied by the well stimulation service provider
 - Secondary pressure protection systems can be one of the following:
 - Spring loaded valves
 - N₂ operated valves
 - M&W Annulus Pressure Relief System (M&W APRS)

Proven Field Experience

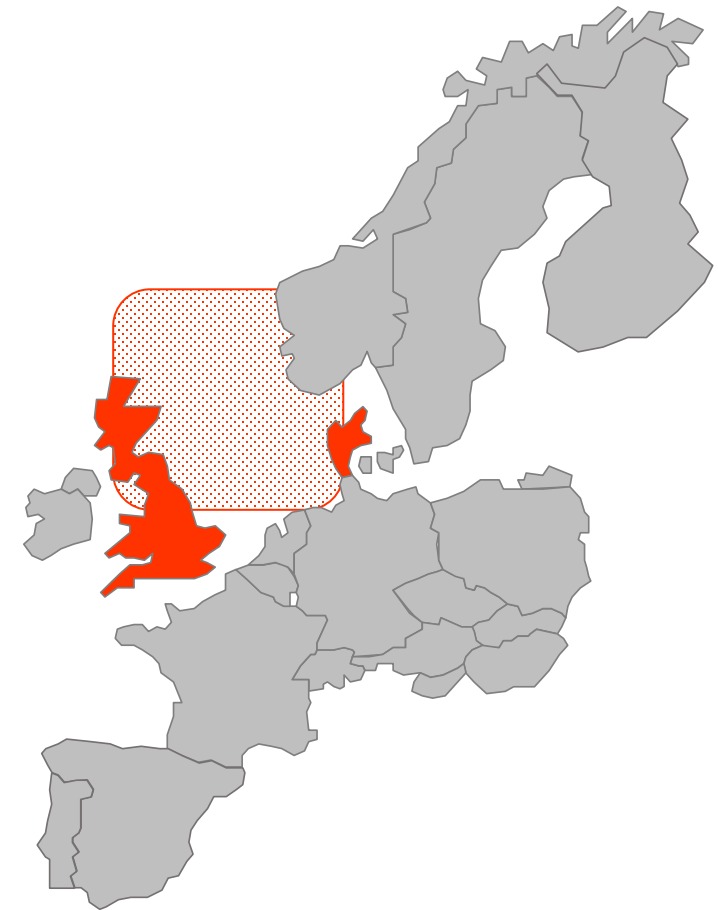
1,000+ well stimulation treatments have been executed since 1995 using the M&W developed APRS system:

- **North Sea, DK (1995-2018)**

-  Dan, Gorm, Valdemar, Bo
-  Dan, Gorm, Valdemar, Bo
-  South Arne
-  South Arne
-  Valdemar 2018

- **North Sea, UK**

-  Ockley 2007 & 2012
-  Ithaca Energy
-  Pierce 2008
-  2018
-  2018



Proven Field Experience

- South China Sea, Offshore Borneo



Bubut 2009

- Kazakhstan, Onshore



MAERSK

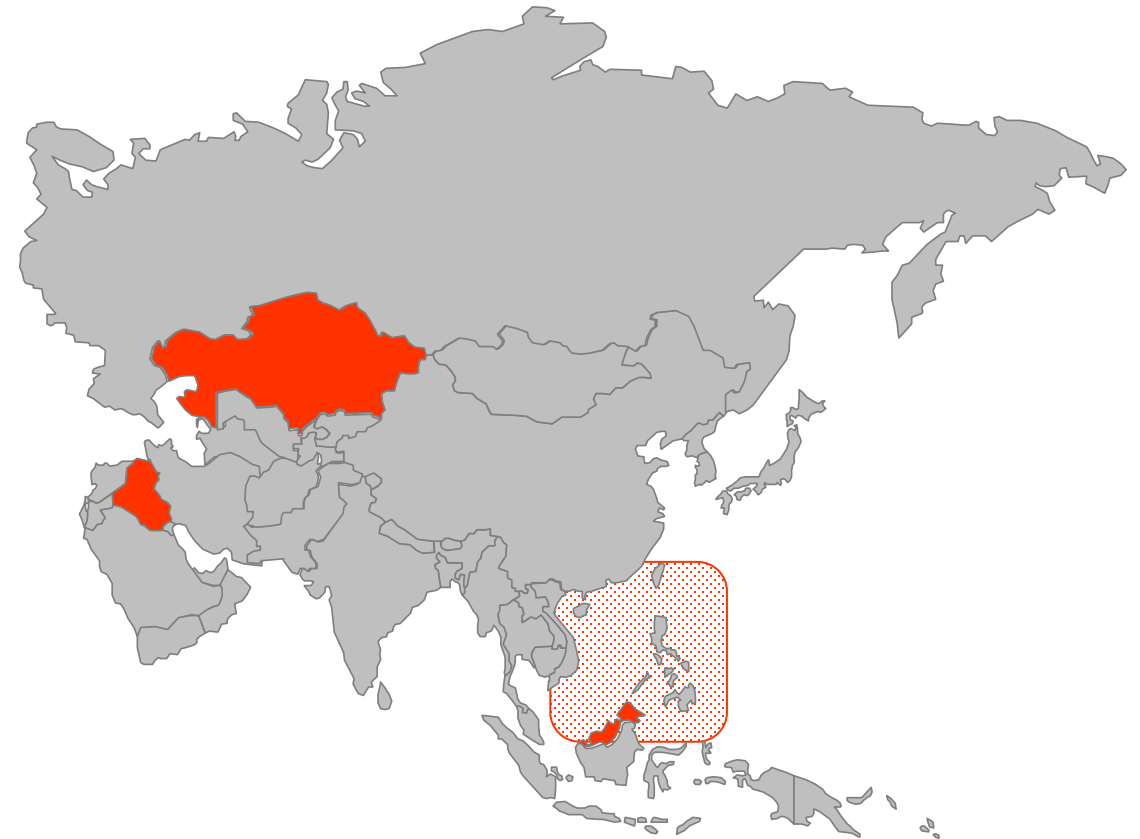
Dunga in Caspian Region 2004-2013

- Iraq, Onshore



* Kurdistan 2019

*Pearl Petroleum Consortium consists of OMV, MOL, RWE, Dana Gas and Crescent Petroleum



What are the benefits?

- High Reliability
 - Based on burst discs (high level of quality control plan)
 - DNV certified
 - No moving parts
 - No welding and no yearly classification is required.
 - Can be installed by rig crew or well services company
- The APRS
 - High accuracy $\pm 5\%$ - though more accurate burst discs can be manufactured on request
 - Several systems can be installed in parallel → isolate blown system and engage backups – fast pressure requirement can be tailormade depending on well formation/requirement (typically 3-4,000 psi, but capable of 7,000 psi and above)



Ruptured burst disc after use

Testimony

“Maersk Oil has over the years done thousands of stimulations worldwide. We started with what the service companies provided as annulus pressure relief mechanism i.e. the spring operated or Nitrogen operated systems.

However, we were not happy with their performance. The provided systems were not reliable as they went off either at too high or too low pressure. That is why we contacted Mark & Wedell to make the burst disc system. We are very happy with this system.

- It is a good and reliable system. It had never let us down and it is easy to use.*
- You can install several M&W APRS systems in parallel, so you can isolate the one that has been blown and continue with backup – fast.*
- M&W runs a 24-7 service and ensures day-to-day delivery always with sufficient burst discs in stock.*

- Jakob Monberg, Senior Lead Engineer, Maersk Oil (Now: Global well stimulation specialist at Total)

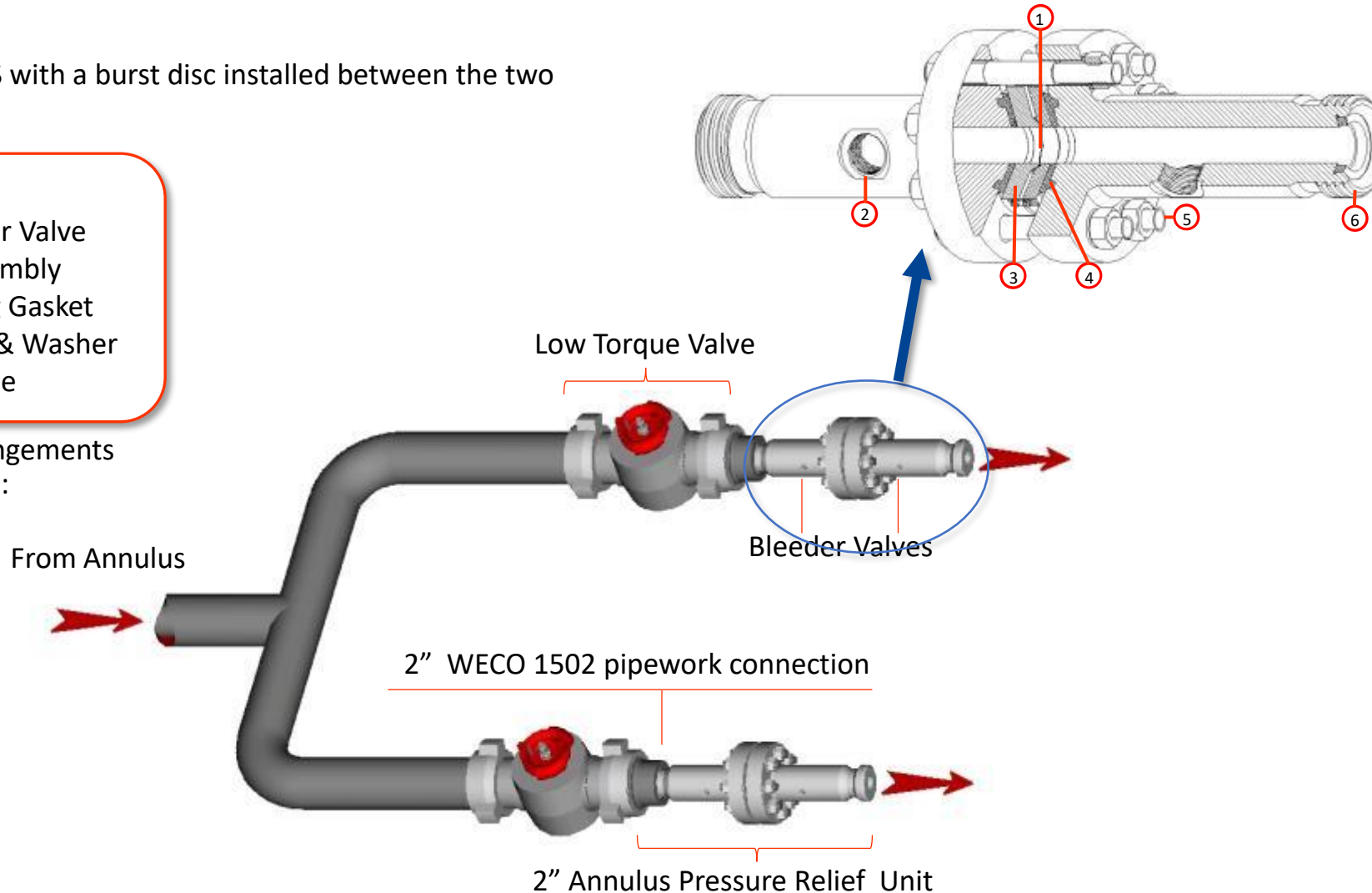


How the M&W APRS is rigged up on the well

- The M&W APRS with a burst disc installed between the two flanges

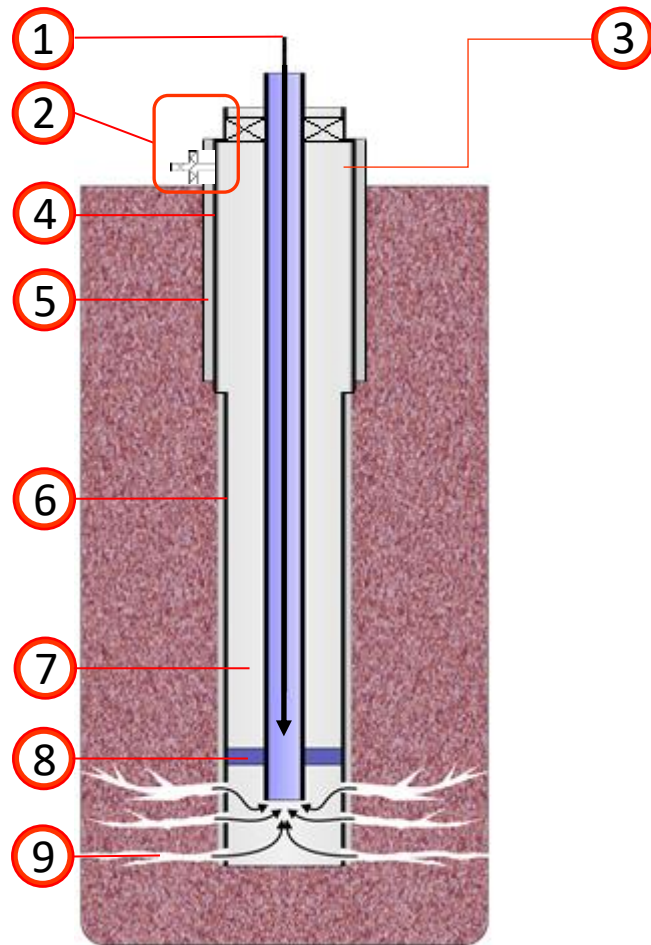
1. Burst Disc
2. Seat for Bleeder Valve
3. Burst Disc Assembly
4. Octagonal Ring Gasket
5. Stud Bolt, Nut & Washer
6. Connection Pipe

Two burst disc arrangements rigged up in parallel:



APRS' Role in a Well Stimulation Job - closed annulus treatment

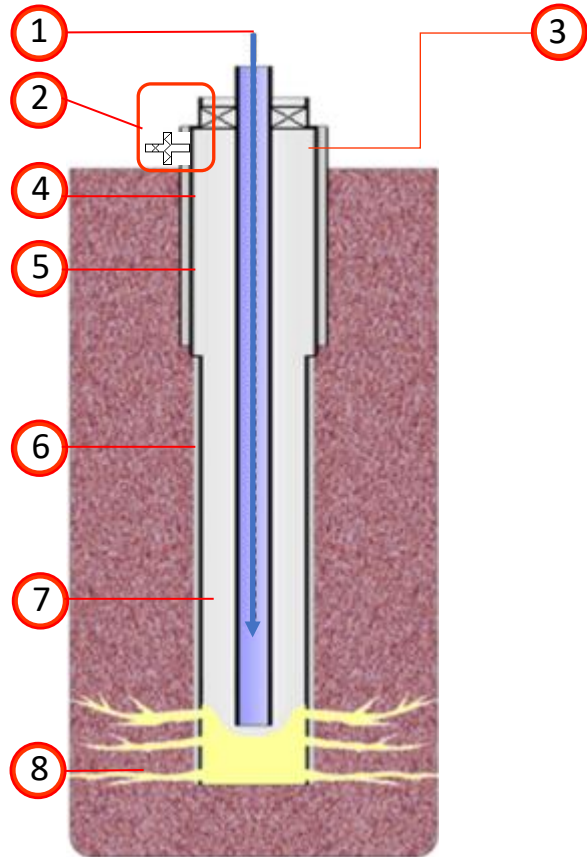
- The production casing is protected from the well stimulation treatment pressure



1. Injection of stimulation fluid
2. Annulus Pressure Relief System
3. Annulus Pressure Electronic Kick-out System
4. Surface Casing
5. Cement
6. Production Casing
7. Production casing tubing or well stimulation string annulus
8. Permanent or temporary packer
9. Stimulation area

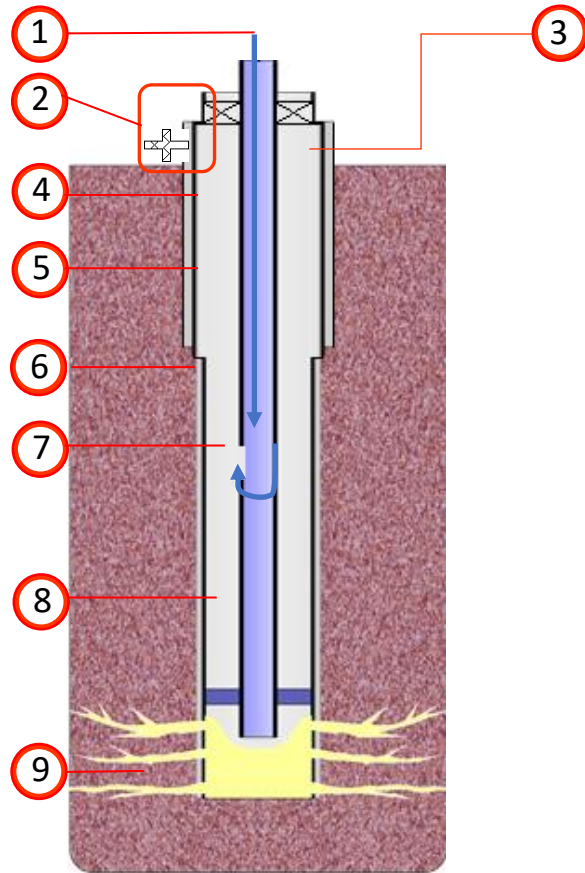
APRS' Role in a Well Stimulation Job - open annulus treatment

- Typical setup for hydraulic with open or live annulus i.e. exposing production casing to well stimulation pressure
- Live annulus allow real-time downhole pressure monitoring



1. Injection of stimulation fluid
2. Annulus Pressure Relief System
3. Annulus Pressure Electronic Kick-out System
4. Surface Casing
5. Cement
6. Production Casing
7. Production casing tubing or well stim. String annulus
8. Stimulation area

APRS' Role in a Well Stimulation Job – leak in string



1. Injection of stimulation fluid
2. Annulus Pressure Relief System
3. Annulus Pressure Electronic Kick-out System
4. Surface Casing
5. Cement
6. Production Casing
7. Leak
8. Production casing tubing or well stim. String annulus
9. Stimulation area

- Leak in tubing (pin holes) damages the casing when exposed to high pressure stimulation → Casing Burst → Could cause a Well Control Situation.
- Tubing leaks may be caused by thermal stress of the tubing, bad connection or etching from the acid stimulation.
- The casing are not rated for the high treatment pressures. Hence, the production must be protected immediately by the pressure relief in the annulus.

Typical Principle of Operation

Install the Annulus Pressure Relief Unit in the pipework routed from the Annulus to the Rig Floor as demonstrated in the arrangement drawing of a typical pressure relief system.

- Check that the Low Torque Valves have the correct dimension.
- Close the two inlet Low Torque Valves.
- Open one of the ½” Bleed Valves.
- Check that the Burst Discs are correctly installed in the Annulus Pressure Relief Units.
- Pressure test all pipeworks including the Weco connections to approximately 80% of the burst pressure and upstream the Low Torque Valves. After pressure test relieve the test pressure.
- Open the Low Torque Valve in question and the Annulus Pressure Relief System is ready for operation.

Typical Principle of Operation - continued

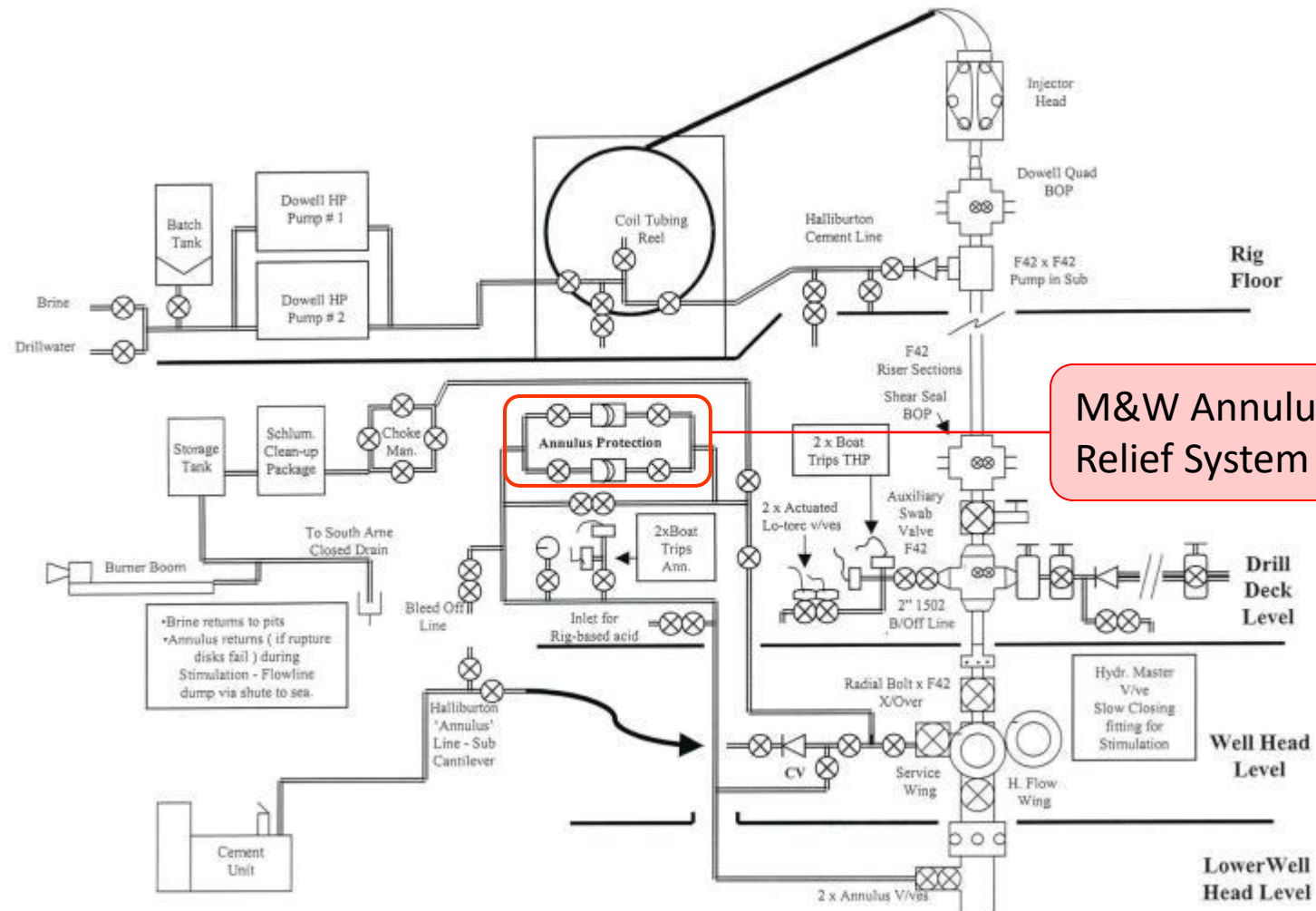
- When the pressure in the Annulus Pressure Relief Unit reach the Burst Disc set point $\pm 5\%$, the disc will burst, and the pressure drops to ambient pressure and the Annulus liquid is routed (typical brine) over the side.
- Close the Annulus Pressure Relief Unit in question and open the back-up burst disc unit.
- After operation exchange any damaged discs.

The Annulus Pressure Relief System is then again ready for operation.

Typical volumes relieved through the APRS:

Treatment rate:	40 bpm	}	Volume = 40 BPM * 1-2 s \approx 0.5 -1.0 bbl
Pump shut down time:	1-2 seconds		

Example: Coil tubing assisted acid stimulation treatment rig-up

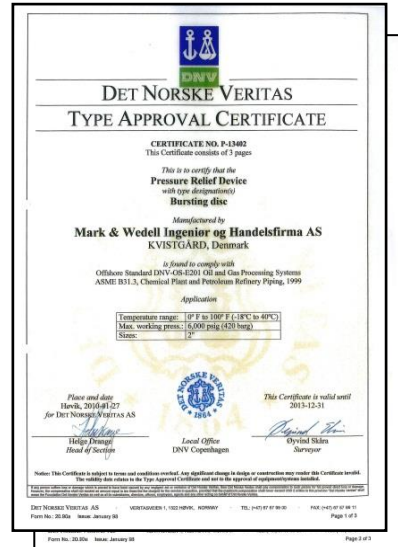


Quality Assurance & Certificates

General Company ISO 9001 approval and certificate



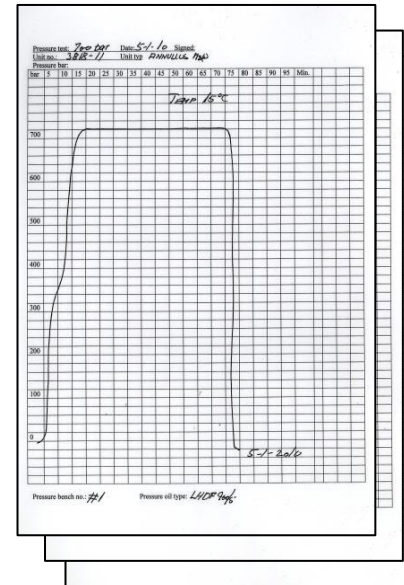
Annulus system type approval and certificate



Materials and components certificates



Tests and test reports



Release



Mark & Wedell – Selected users of the APRS



MAERSK



RWE



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