"Cost Effective Capillary Tubing Installation In Coiled Tubing"

September 16, 2009

10th Jubilee International Coiled Tubing and Well Intervention Conference
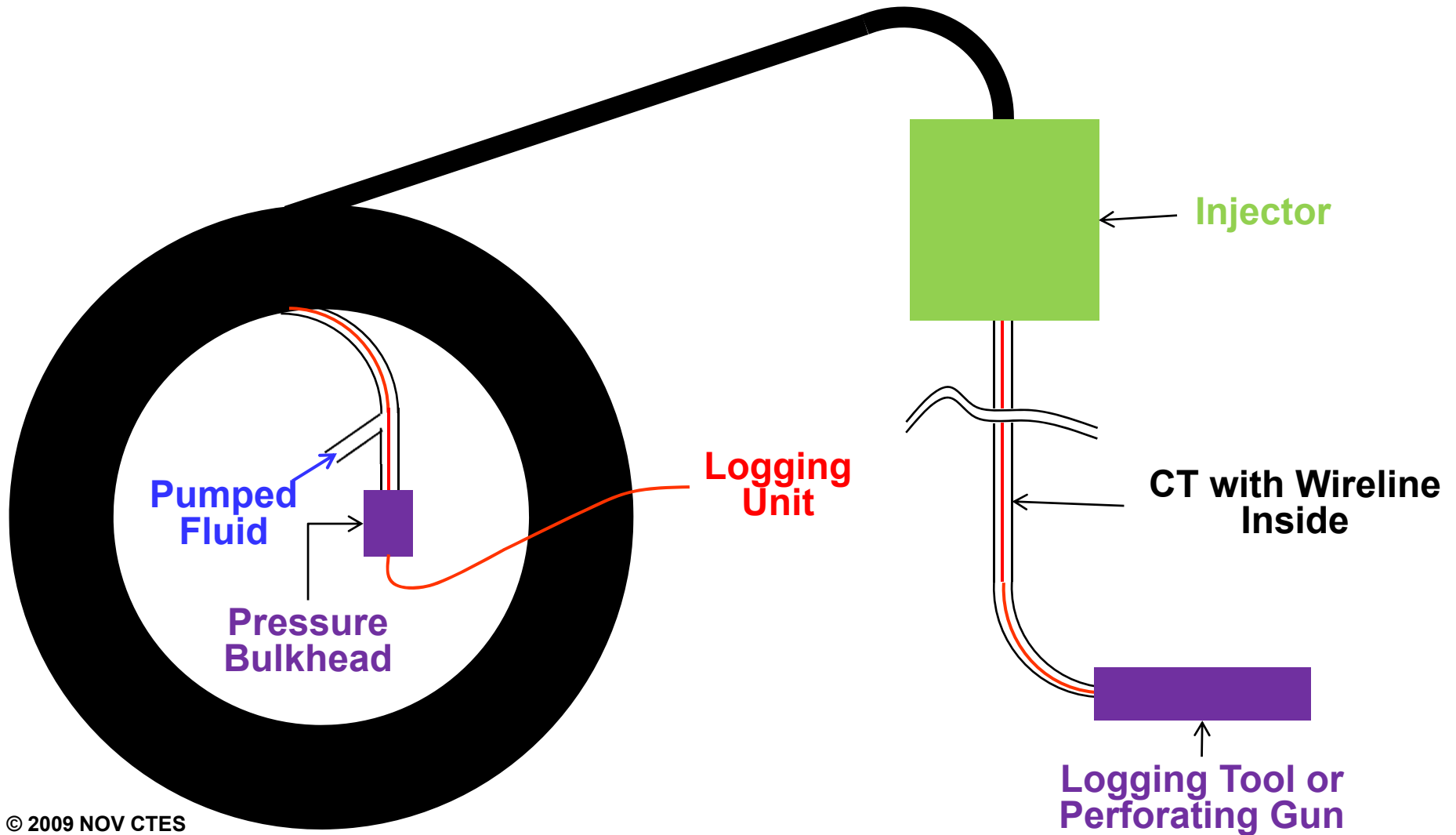
Moscow, Russia

Ken Newman – NOV CTES

Why Install Wireline or Capillary Tubing in CT?

- **Wireline inside CT**
  - Used to push tools into horizontal wells
  - CT logging / perforating started in 1988

- **Capillary tubes**
  - Used as hydraulic tubes to hydraulically operate downhole tools
  - Used to protect fiber optic cable inside the capillary tube

- **Both Wireline and Capillary Tube(s)**
  - Hydraulically orient the BHA for directional CT drilling
  - Read the bottom hole data (inclination, azimuth, orientation, pressure, WOB, TOB, etc.) in real time

CT Logging System
(Electric wireline installed inside of CT)

Injector

CT with Wireline Inside

Logging Tool or Perforating Gun

Logging Unit

Pumped Fluid

Pressure Bulkhead

Methods of Installing a Wireline or Capillary Tube Inside the CT

- **Vertical Installation**
  - Hang CT in a well
  - Drop the wireline or capillary tube into the CT

- **Horizontal Installation**
  - Lay the CT straight along a road
  - Use a 'pig' to pump the wireline or capillary tube through

- **NOV CTES Cable Installation System**
  - Uses turbulent flow of pumped fluid to rapidly 'float' the wireline into the CT (no pig)
  - Now it is possible to use turbulent flow of pumped fluid to rapidly 'float' a capillary tube into a CT string (no pig)
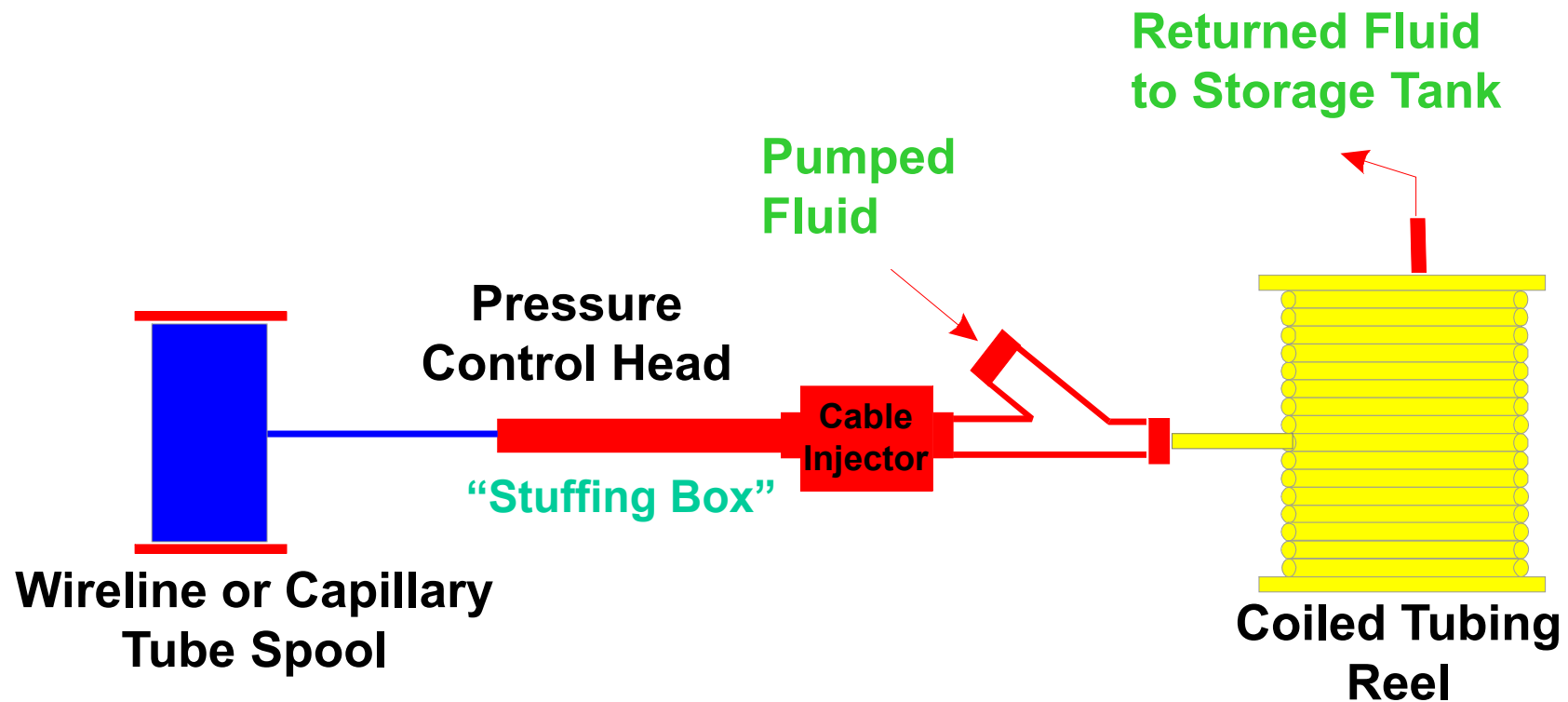
Cable Slack Management
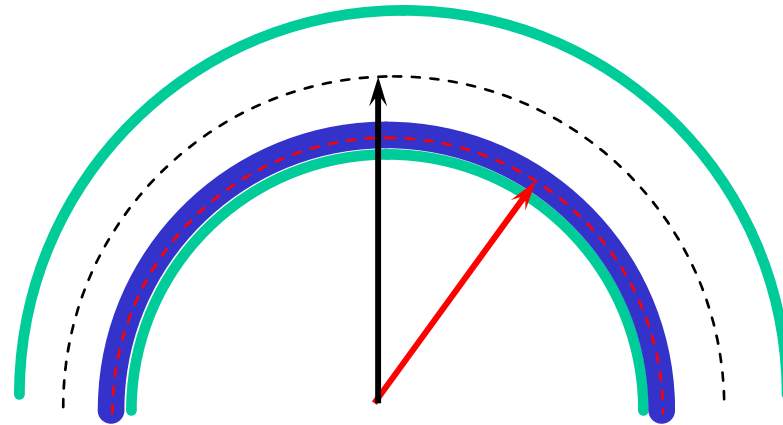
Centerline radius of CT is about 1% greater than centerline radius of cable (if cable is tight)

Extra cable (slack) must be installed to insure there is more cable than CT

NOV CTES Cable Installation System

Returned Fluid to Storage Tank

Pumped Fluid

Pressure Control Head

Cable Injector

"Stuffing Box"

Wireline or Capillary Tube Spool

Coiled Tubing Reel

Reduces Installation Cost by at least 4X

How the Cable Installation System Works

- Water is pumped through the CT fast enough to cause turbulent flow.
- The turbulent flow causes the cable to flutter inside the CT, eliminating friction.
- The viscous drag forces along the cable cause it to move forward.
- No 'pig' is used. It would cause tension in the cable which would cause it to lock in the CT.
- The high pump pressure tries to blow the cable backwards out of the pressure control head.
- The cable injector uses a capstan wheel to pull the cable into the pressure.

A Capstan is a Tension Multiplier

$$T_{out} = T_{in}e^{\mu\beta}$$

- **μ is the friction coefficient**

- **β is the number of radians of revolution**

- **For 6 revolutions β = 6*2π = 37.7**

- **Assume μ = 0.2, T_{out} = 1,881 * T_{in}**

10,000 psi Cable Injector

Stuffing Box

Footage Counter

Cable

CT

10,000 psi Cable Injector

Cable Injector Schematic

Hydraulic Motor

Cable Outlet

Cable Inlet

Shear Ring

Breach Plug

Stator Ring

Capstan Drum
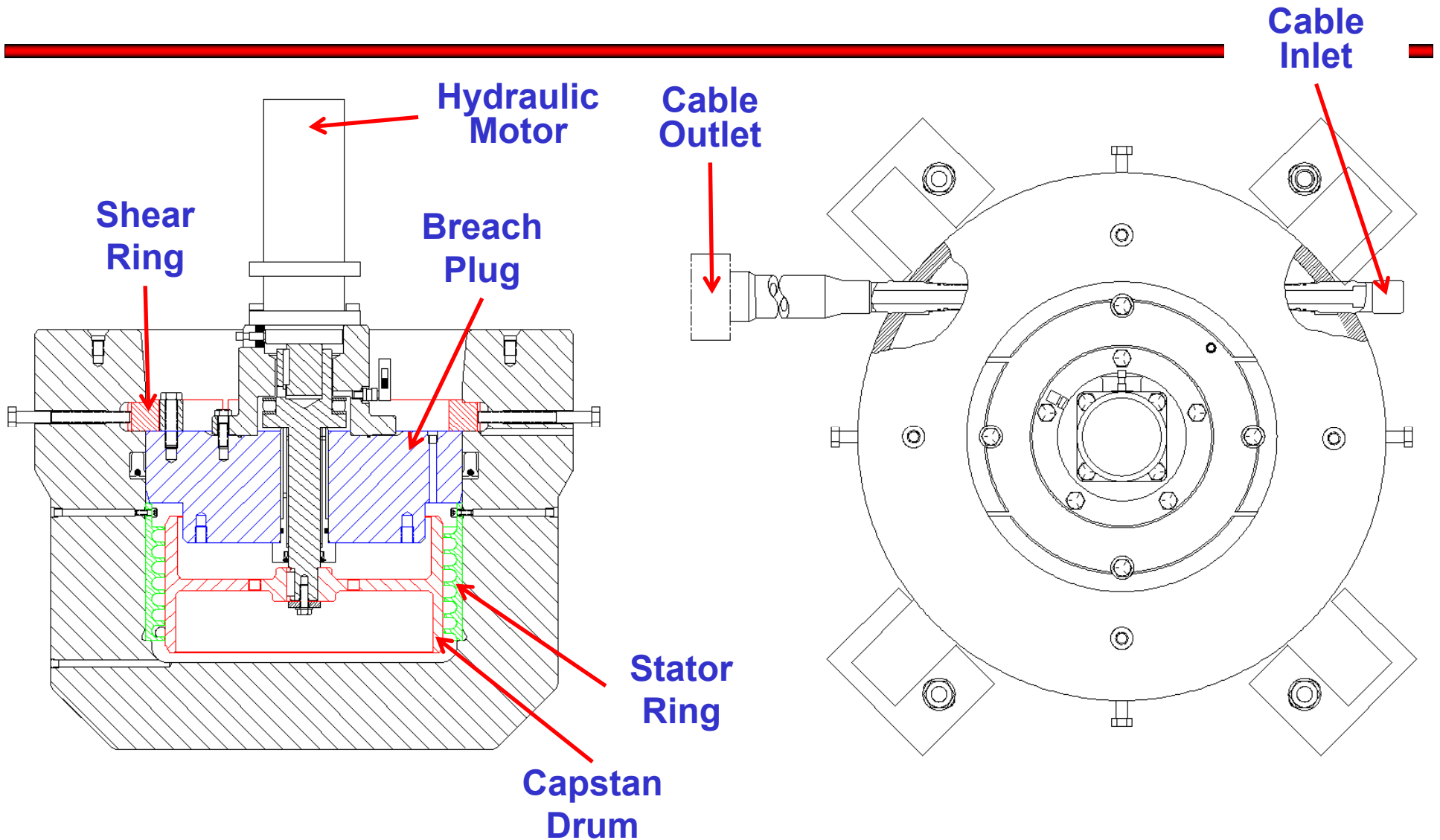
Location Setup

Pressure Control Head Intended Use

- **Consists of:**
  - 3 "flow tubes", with a design ID only 0.005" larger than the OD of the cable
  - 1 polyurethane packer at the low pressure end

- **Built for wireline pressure control**
  - When used in a wireline operation, grease would be injected at a pressure higher than wellhead pressure, at the high pressure end of the control head
  - Grease returns to the grease tank from the low pressure end, just before the polyurethane packer

Pressure Control Head
As Used

Water Return
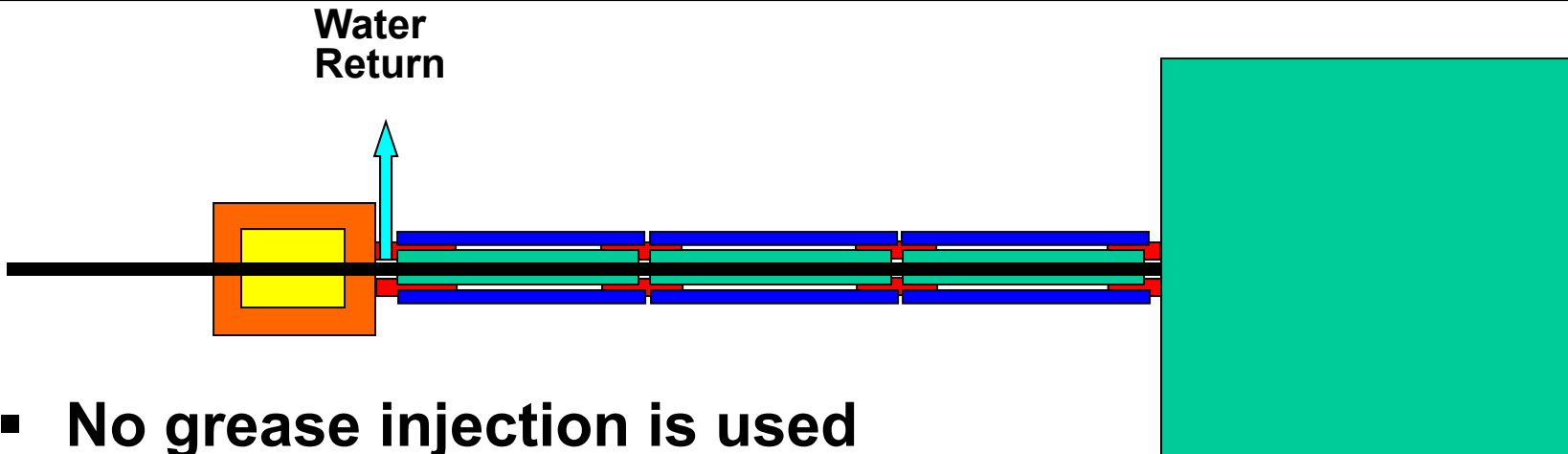
- **No grease injection is used**
  - Grease lubricates the cable, reducing the friction and making the capstan less effective
  - A perfect seal (obtainable with grease) is not required because only water is being used
- **The flow tube clearance can be larger than TOT intended. The water return volume increases with increased clearance**

First Capillary Tube Installation
June 2009 at Tenaris Coiled Tubes

- **Capillary Tube**
  - 316 SS - 0.25" OD, 0.049" wall
  - 6.4mm OD, 1.24mm wall

- **Coiled Tubing**
  - HS-70 - 1.25" OD, 0.095" wall
  - 31.75mm OD, 2.41mm wall
  - 5,600' (1,706m) long

- **Operation**
  - 5/16" (7.93mm) flow tube
  - CT spooled on large reel
    - » 12.5' (3.8m) core dia
  - Max pump pressure
    - » 9,000 psi (621 bar)
  - 150 ft/min (46 m/min)
  - 150' (46m) slack (2.6%)

Conclusions

- **Wireline has been installed using cable installation systems since 1994**

- **Now capillary tubes can be installed using the same system with minor modifications**

- **Future systems are being considered:**

  - **Allow installation of up to 3 things at one time**

  - **Operating pressure of 15,000 psi (1,034 bar)**