Waste Injection (CRI) Pump Units

Applications:

- Waste Injection/Cuttings Injection
- General Well Service & Well Completion
- Acidising, Pressure Testing and Well Kill
- Cementing
- Coil Tubing
- Mud Pumps

Introduction

Calder Ltd has established a reputation over a period of 30 years as a designer and supplier of robust, functional and reliable High Pressure Pumping equipment for waste injection applications around the world. Every Calder Waste Injection unit incorporates the proven inherent attributes of quality and reliability whilst matching individual installation requirements.

A range of plunger sizes is available for the Calder Waste Injection pumps; the optimum size is selected for each particular application. This ensures that a wide range of flows and pressures can be achieved without the need for subsequent changes of plunger.

The control system requirements are uncomplicated and easily accommodated by a range of solutions from relay logic to remote, networked PLCs.

The Calder Waste Injection pump packages can also be utilised for general well service, well completion and cementing duties, provided that these duties are defined and included in the selection criteria.

The primary pump components; plungers, packings, valves and lubrication systems are selected on the basis of comprehensive oil-field experience. The pump satisfies API 674 rules (with some minor exceptions).

Through experience, Calder Ltd has identified the key elements required to package reliable, operable and maintainable equipment.

Model: CRI 450 & CRI 1680
450kW to 1680kW (250HP to 2500HP)

94/9/EC ATEX - 97/23/EC - PED
2006/42/EC Machinery Directive
CE Marked
Waste Injection (CRI) Pump Units

The pump unit is designed to continuously inject slurry over a wide range of flows and pressures, for the injection of seawater and slurries consisting of drill cuttings, drilling muds and sand into subsea strata as demanded by the oil drilling industry worldwide. Derivatives of this Calder-designed package are being used in Canada, Siberia, Caspian Sea, UK North Sea and Norwegian North Sea.

Experience

Calder Ltd has identified the key elements required to package reliable and easily maintainable equipment in the most arduous conditions. These key elements are included in the standard Calder package or are offered as options where applicable.

The range of options ensures that the scope can be adjusted to meet each project’s specific needs. Calder Ltd will work alongside clients to assist in specifying associated equipment, such as drives and controls, should the client choose to source these separately.

Calder has the experience and capability to offer a wide range of services, including original design, testing and on site service support over a wide range of oilfield applications.

In addition to waste injection/well service pumps we offer a range of packages up to 2.5 MW power capacity and pressures up to 4000 bar.

Hydraulic Motor Drive

- Full range flow adjustment.
- Small footprint.
- Smooth operation.

Description

The Calder Waste Injection pump package consists of a high-pressure reciprocating plunger pump and driver (electric motor with variable frequency drive (VSD) or hydraulic pump/motor; alternatively diesel engine driver with six speed transmission or hydraulic pump/motor) which are mounted on a substantial base frame. The package includes packing lubrication and power end lubrication sub-systems and associated instrumentation.

The variable speed drive capability provides variable flow over a range from 10% to 100%. The pump unit can be controlled from the skid or from a remote operator station.

Flow control allows the operator to select the required flow rate at the pressure that is within the wellhead, providing the pressure does not exceed the design rating of the pump and motor. The HP pump delivers a flow that is proportional to the motor speed and at the pressure necessary to inject the slurry.

Calder Ltd offers a range of options such as a noise hood, oil heaters and oil coolers to suit the process and installation requirements of the specific project.

A full range of Functional Tests at full flow and pressure are completed before despatch from Calder’s works to ensure that commissioning can progress without delays. The package can be readily transported and installed on the platform, supported with comprehensive certification and technical literature.
CRI Design Criteria:

The self-contained Waste Injection high pressure units are designed and built in the UK to conform to most international oil and gas field requirements compliant with ATEX, Norsok or Gost regulations and standards for use in a Safe Area, Zone I or II hazardous area. The high-pressure pump is selected for continuous duty service ensuring long-term reliability and low maintenance in the field.

Variable speed drive options ensure that the optimum speed torque envelope is maintained with minimum current demand. Where VSD is selected the frequency converter minimises harmonic distortion and EMC radiation providing a high frequency switching and recalculation against the motor model, thus providing rapid and direct control of the drive motor.

The control system provides programmable analogue and digital inputs and outputs, keypad entry, text read-out for the various parameters including frequency, current, torque and power. A range of additional management and communication facilities are available for connection to the system.

Injection rates and discharge pressures will determine the pump selection and ultimately the power required. The standard pump package supplied by Calder is a ready-to-go machine complete with all termination points at skid edge, complete instrumentation, pulsation dampers, safety relief valves, junction boxes and control systems. Finite element analysis (FEA) is supplied to primary structures and can be extended to include ‘Blast Case’ analysis.

The Unit Comprises:

- High pressure pump, gearbox and driver.
- Pressurised lubrication system with oil cooler.
- HP pressurised packing lube system.
- Integral suction & discharge dampers.
- Discharge pressure safety valve (suction PRV option).
- Temperature & pressure transmitters.
- Stroke counter or flow meter.
- Non-sparking coupling guard.
- Instrumentation, E stops and associated wiring to local JB.
- Anti-vibration mounts (AVM).
- Fully flexible control of the injection system to meet well-head requirements.
High Pressure Pumps

The Calder CRI triplex reciprocating plunger pumps conform generally to API 674.

The pump fluid ends are manufactured from forged steel designed with easy maintenance as a priority, giving fast access to valves, packings and plungers. (Duplex and Super Duplex Stainless Steel are available as options.)

The internal suction & discharge valves are designed specifically for aggressive slurry injection processes. These valves have clear flow-ways and specially formulated polyurethane replacement inserts for resistance to acids and abrasives.

The plunger packing system is the SSF design combined with ASF Flat Back Seal Ring and Header Rings, which are specially designed for use on slurry applications. Plungers are 4330 Alloy 6, coated with Boron Alloy that provides maximum hardness for erosion and wear resistance. A packing lubricator is fitted to enhance the life of high pressure packings.

Suction and discharge flanges to the Calder CRI pumps are provided to suit the customer’s specific requirements. As standard, the pump’s discharge fittings are Weco fig.1502 with ANSI 150 lb RF. 6”, 8” or 10” suction terminations to suit flow conditions.

The power end of the high-pressure pump is a heavy-duty steel fabrication with a one-piece forged steel crankshaft. The four main bearings are large straight roller bearings with shell type replacement journal bearings.

A speed reducer gearbox with 4.68:1 to 7.5:1 ratios is fitted directly to the power end of the pump. The reduction is achieved through a double heavy-duty helical gear machined from alloy steel, heat-treated and crown shaved.

A drip tray is installed under the entire HP pump, including the pump head.

Drive Options Available:

- Electric motor, AC variable speed.
- Electric motor with hydraulic pump and hydraulic motor.
- Diesel engine drive through semi-automatic transmission.
- Diesel engine drive through hydraulic pump and hydraulic motor.
The power selected for the motor is based on the duties specified plus allowances for PSV set pressure and PSV overpressure. This selection provides a particular performance envelope to suit specific well conditions.

Electric motor driven units can be Safe Area to Zone 1, II 2 G EEx de IIC T4 in accordance with guiding rules 94/9/EG ATEX. Diesel engine driven units are normally Safe Area or Zone 2 compliant.

**Options**

Calder Ltd offers a range of options. Some options are mutually exclusive of others.

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**Packing Lubrication System**

The packing lubrication system mounts directly to the HP Pump. Packing lubrication oil is stored in a small reservoir, a series of 3 lubricator pumps are mounted into the reservoir each feeding fluid directly into the lantern ring within the packing sets. The pumps are driven from a common shaft, taking power from the HP pump crankshaft via a “V” belt drive.

This system provides precise measures of lubricant under pressure into the packing based on pump speed. An optional large capacity packing oil header tank is available.

**Power End Lubrication System**

A 4.6 kW, 3-phase electric motor will independently drive the lubrication gear pump. This ensures a constant feed to all critical components within the power end at all HP pump speeds. This is particularly important at low speed high pressure duties.

The oil is stored in an integral steel tank and is lifted from the tank by the pump, filtered to 20 microns and injected onto the bearing and gear surfaces within the power end of the HP pump; from there the oil drains from the HP pump back into the lube oil storage tank.

Additional instrumentation, oil heaters and oil cooler are available, as required to suit the environmental conditions.
Waste Injection Pumps
Client ........ BP
Flow ........... 95m³/hr (10 bpm)
Pressure ........ 345 bar (5000 psi)
Hazard Area ... Zone 1 ATEX
Drive ............ 1400kW variable speed
Noise ............ 83 db(A)

Well Service Pumps
Client ........ Aker
Flow ........... 105m³/hr (11 bpm)
Pressure ........ 517 bar (7500 psi)
Hazard Area ... Safe Area
Drive ............ 1800kW variable speed
### Power tables show approximate (kW) power absorbed at various flows and pressures

### Calder Cuttings Injection Pump Model CRI-450

#### Pressure flow chart for all plunger sizes

| Pressure | Flow | 13 | 26 | 50 | 67 | 77 | 92 | 102 | 119 | 126 | 134 | 150 | 164 | 164 | 185 | 235 | 248 | 256 | 306 | USGPM |
|----------|------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
| 50       | 100  | 188 | 250 | 290 | 350 | 385 | 416 | 485 | 540 | 568 | 620 | 742 | 850 | 939 | 970 | 1158 | LPM |
| 6.3      | 0.6  | 1.2 | 1.6 | 1.8 | 2.2 | 2.4 | 2.6 | 3.0 | 3.4 | 3.6 | 3.9 | 4.7 | 5.3 | 5.9 | 6.1 | 7.3 | BPM |
| 10       | 110  | 188 | 250 | 290 | 350 | 385 | 416 | 485 | 540 | 568 | 620 | 742 | 850 | 939 | 970 | 1158 | LPM |
| 25       | 140  | 253 | 325 | 389 | 431 | 462 | 495 | 581 | 634 | 673 | 793 | 969 | 1057 | 1138 | 1255 | 1515 | USGPM |

- **Crankshaft speed is limited to 450 RPM maximum. Max recommended speed for Slurry Service should not exceed 200 rpm. 450 kW (600 HP) maximum Intermittent Pump 300 kW (400 HP) Maximum Continuous Duty.**

### Calder Cuttings Injection Pump Model CRI-1680

#### Pressure flow chart for all plunger sizes

| Pressure | Flow | 26 | 132 | 264 | 370 | 431 | 462 | 545 | 581 | 634 | 673 | 793 | 969 | 1057 | 1138 | 1255 | 1515 | USGPM |
|----------|------|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 50       | 100  | 500 | 1000| 1400| 1631| 1750| 2062| 2200| 2400| 2547| 3000| 3667| 4000| 4307| 4750| 4992| 5734| LPM |
| 6.6      | 3.1  | 6.3 | 8.8 | 10.3| 11.0| 13.0| 13.8| 15.1| 16.0| 16.9| 23.0| 25.1| 27.1| 30.9| 34.9| 36.0| 39.5| BPM |
| 25       | 363  | 5   | 26   | 52   | 72   | 84   | 90   | 106  | 113  | 124  | 131  | 155  | 189  | 206  | 222  | 245  | 257  | 296  |
| 50       | 725  | 10  | 52   | 103  | 144  | 168  | 180  | 213  | 227  | 247  | 263  | 309  | 376  | 412  | 444  | 490  | 515  | 591  |
| 75       | 1088 | 15  | 77   | 155  | 218  | 252  | 271  | 319  | 340  | 371  | 394  | 464  | 567  | 619  | 666  | 735  | 772  | 887  |
| 100      | 1580 | 20  | 108  | 236  | 280  | 338  | 361  | 425  | 454  | 495  | 525  | 610  | 756  | 923  | 888  | 979  | 1029 | 1182 |
| 105      | 1715 | 25  | 151  | 303  | 359  | 404  | 435  | 505  | 544  | 594  | 652  | 760  | 973  | 1113 | 1237 | 1313 | 1456 |
| 200      | 2900 | 40  | 206  | 412  | 577  | 673  | 722  | 850  | 907  | 990  | 1050 | 1237 | 1512 | 1646 | 1912 | 2195 | 2644 |
| 250      | 3625 | 50  | 258  | 515  | 722  | 841  | 902  | 1063 | 1134 | 1237 | 1313 | 1546 |
| 300      | 4500 | 60  | 329  | 659  | 918  | 1069 | 1173 | 1382 | 1474 | 1708 | 1912 | 2320 |
| 375      | 5438 | 70  | 387  | 773  | 1082 | 1261 | 1353 | 1594 |
| 400      | 5800 | 75  | 422  | 825  | 1159 | 1345 | 1443 |
| 416      | 6163 | 80  | 476  | 976  | 1392 | 1554 |
| 500      | 6525 | 90  | 496  | 928  | 1299 | 1513 | 1624 |
| 475      | 6888 | 95  | 500  | 1001 |
| 525      | 7613 | 100 | 584  | 1082 | 1515 |
| 550      | 8075 | 105 | 587  | 1134 | 1588 |
| 575      | 8338 | 110 | 593  | 1186 | 1660 |
| 600      | 8700 | 115 | 619  | 1237 |
| 625      | 9063 | 120 | 644  | 1289 |
| 650      | 9425 | 125 | 670  | 1340 |
| 700      | 10150| 130 | 722  | 1443 |
| 600      | 11600| 135 | 625  | 1649 |
| 900      | 13690| 150 | 817  | 1929 |
| 1000     | 14500| 155 | 882  | 2063 |
| 1100     | 15950| 160 | 913  | 2134 |
| 1200     | 17400| 165 | 949  | 2237 |
| 1300     | 18934| 170 | 984  |

- **Crankshaft speed is limited to 330 RPM maximum. Max recommended speed for slurry service should not exceed 200 rpm. 1687 kW (2250 HP) maximum Intermittent pump 850 kW (1100 HP) maximum continuous duty. Power tables show approximate (kW) power absorbed at various flows and pressures. Power and flow for each plunger size. All data is based on 95% volumetric efficiency and 85% mechanical efficiency pressure and flow limits for each plunger size.**

#### Power Table: Calder CRI 450 Pump

- 5.0" Plunger
- Pressure limit 351 bar
- 4.5" Plunger
- Pressure limit 433 bar
- 4" Plunger
- Pressure limit 548 bar
- 3.5" Plunger
- Pressure limit 716 bar
- 3.0" Plunger
- Pressure limit 976 bar

#### Power Table: Calder CRI 1680 Pump

- 7.5" Plunger
- Pressure limit 375 bar
- 6.5" Plunger
- Pressure limit 525 bar
- 5" Plunger
- Pressure limit 600 bar
- 6" Plunger
- Pressure limit 700 bar
- 4" Plunger
- Pressure limit 1000 bar
- 4.5" Plunger
- Pressure limit 1300 bar
Waste Injection (CRI) Pump Packages

**Performance**

Calder pump packages are designed for intermittent & continuous pumping of Oil & Gas field waste products & well service chemicals such as, Brine, Drill Cuttings & Muds within a specified duty range.

- **Pressure Range** ............... 80 to 1400 bar (1,200 to 20,000 psi)
- **CRI 450** .......................... 156 M³/hr (16 BPM)
- **CRI 1680** .......................... 344 M³/hr (36 BPM)
- **Flow range** ........................ 10% to 100%
- **Power range** .................... 450 kW to 1680 kW,
- **Safe or Hazardous area** .... ExN or EExd, Zones 1 & 2
- **Noise Level** ..................... 75 dbA, 83 dbA, 85 dbA @1M

**Drive Options**

- Electric Motor, Fixed or Variable speed using VFD or Hydraulic Drive
- Diesel Engine with Transmission or Hydraulic drive.

**Unit Configuration Options**

- Open Skid, Trailer or Truck Mounted
- Noise & Environment Enclosure.
- Container, Offshore DNV compliant

**Pump type for Waste Injection (CRI) process:**

- Reciprocating Pump Type..... Calder Model CRI 450 & CRI 1680 Triplex Reciprocating Plunger.
- Plunger Range (diameter)..... 57 mm to 180 mm (2.25" to 7.0")
  Plunger (stroke 150 & 200mm)
- Plunger Material Type......... SS/Tungsten Carbide
- Valve Housing..................... High Strength Alloy Steel or Duplex stainless steel (option)
- HP Seals ................................ SSF Design with back seal ring,
  Lantern & Oil Lube
- LP Sealing ................................ Double Lip Seal
- Lubrication .......................... Pressurised - filtered
- Suction Flange ...................... 6" or 8" 150lb ANSI Raised Face

**Discharge Flange**

To suit client requirements.
- **Design Temperature** ......... 10°C to 85°C
  (-40°C + 120°C options)
- **API 674** .......................... Compliant with exceptions

**Operation & Control Systems:**

Simple Controls to fully integrated unmanned control systems. Pump flowrate controls allow fixed or variable flow rates using variable frequency drive or hydraulic drives.

**Pump unit control system configurations featuring the following options:**

- Single or multiple pump unit control systems which can be operated from a remote location.
- Local control systems available which can be skid mounted.
- Full integration and interface with client to control systems.
- Use of the latest communication protocols.
- Comprehensive instrumentation with health/status monitoring functions.
- Full data acquisition and logging capabilities.
- Optional touch-screen HMI with manual or automatic modes.

During operation the system is protected by instruments monitoring the suction pressure, the discharge pressure, the lube oil pressure and the lube oil temperature. The control system also monitors its own internal communications. If any of these are lost, the whole system is shut down immediately. An external communication port is available for remote operation and monitoring.

**Standards & Specifications:**

Calder pump packages can comply with most international standards and specifications including:

- ATEX  |  IEC  |  GOST  |  EN  |  DNV  |  API  |  ANSI  |  PED  |  AS/NZ  |  NORSOK  |  NACE  |  CE  |  PED

ISO 9001 Quality standard has been practised by Calder since 1987 with award of certification in 1999. Our rigorous application of this highly respected International Quality Standard has ensured that we consistently meet and exceed our customers’ most demanding expectations for both quality and reliability.

ISO 14001 Environmental Standard has been held by Calder since 1999. Careful and judicious management of our working environment with the application of sound and well informed design applications utilising the latest and most efficient technologies helps us to produce equipment which minimises the environmental footprint of our production facility and the operating equipment in the field.

OHSAS 18001 We at Calder pride ourselves on our safety record. As members of the British Safety Council we practise the strictest safety procedures within our factory and working environments, applying rigorous risk assessments to all activities and equipment which we design and build.