SME Mining Conference

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Technical Presentation

"VARIABLE SPEED DIRECT HYDRAULIC DRIVE (DHD) APPLICATIONS AND ITS RECENT TECHNICAL DEVELOPMENTS FOR THE MINING AND BULK MATERIAL HANDLING INDUSTRY "

Presented By

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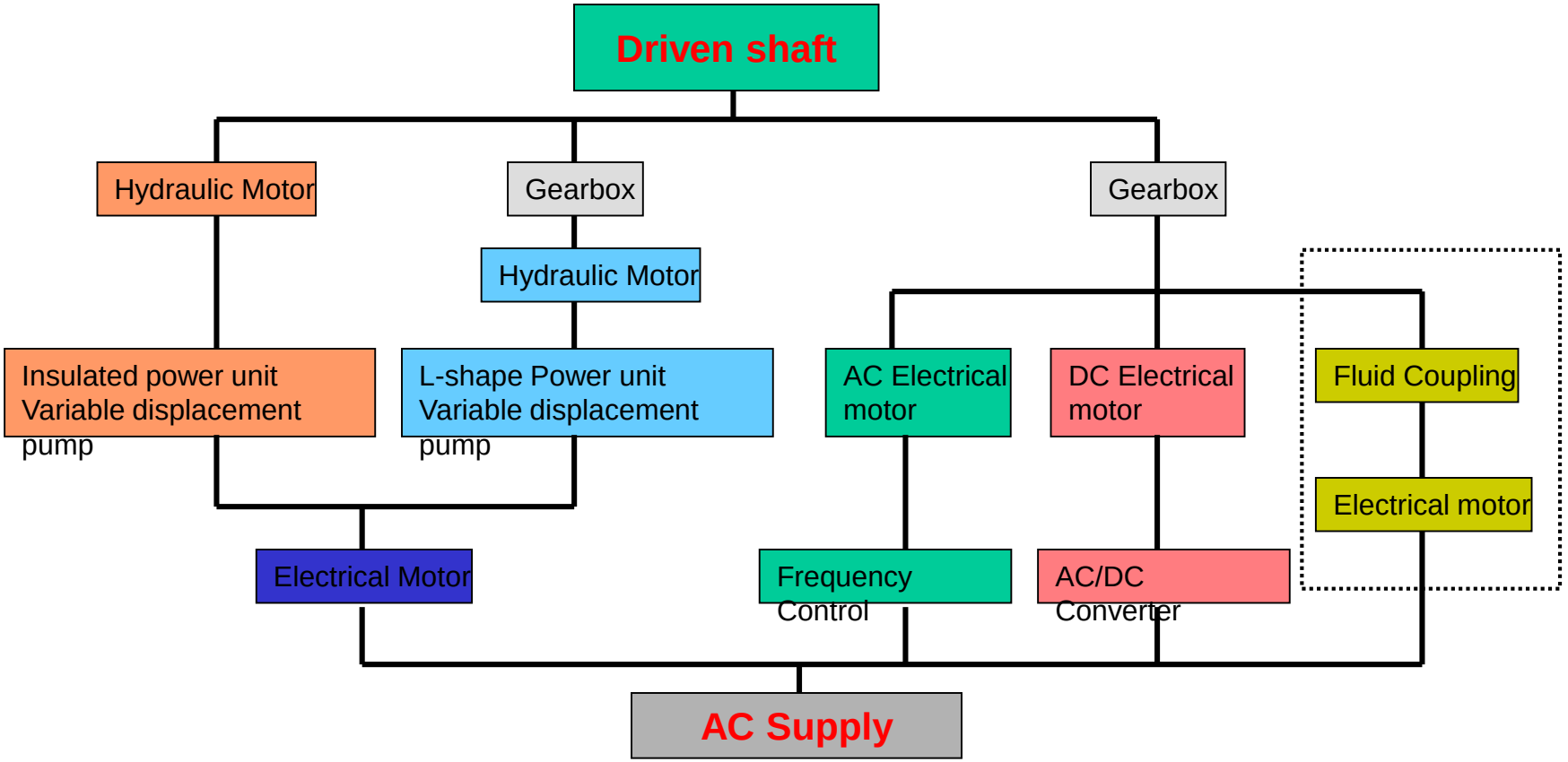
HÄGGLUNDS

AGENDA

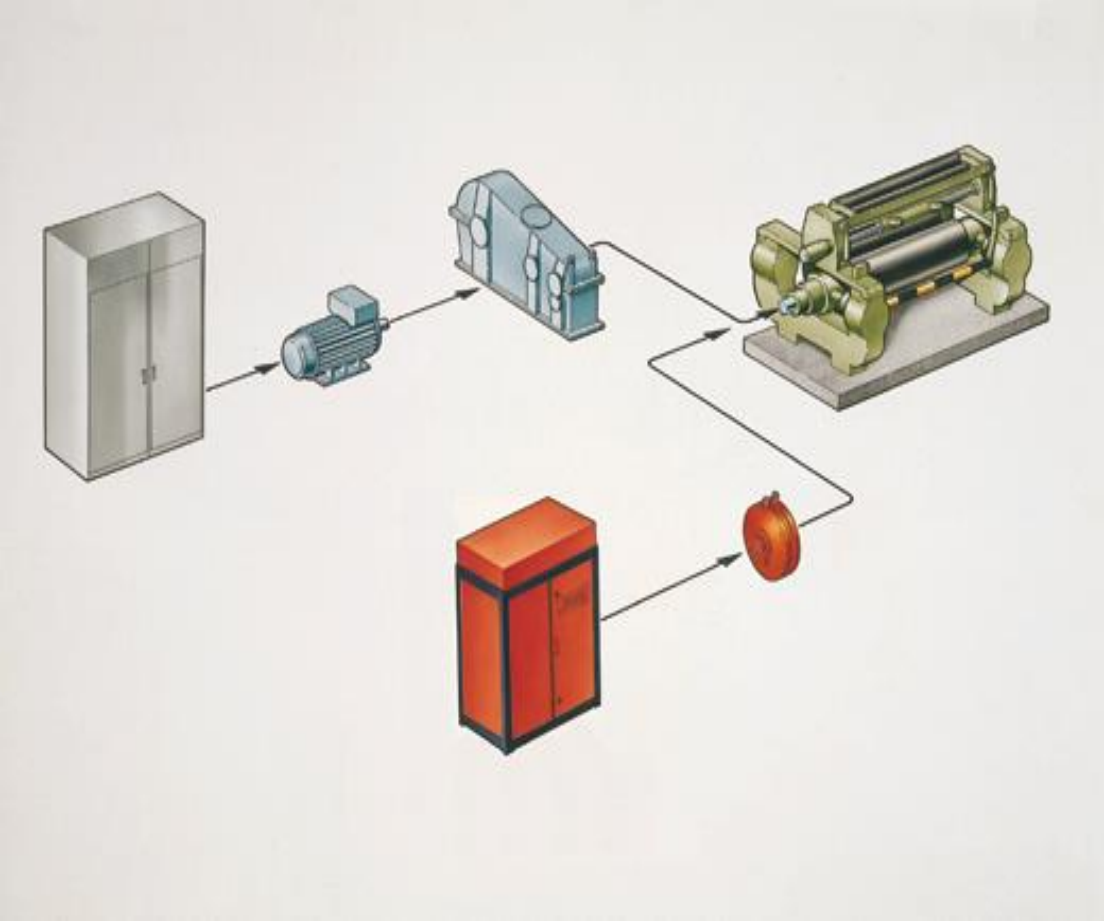
- Alternatives of LSHT Drives
- The Concept of DHD (Direct Hydraulic Drive)
- Principle of Operation for DHD
- Continuous Technical Development of DHD
- Comparison of Various Drives, Performance, Efficiency, Service life
- Distinct Features and benefits of DHD
- Applications in Mining & Material handling
- Conclusion

Alternatives of Variable Speed Drives



Variable Speed Drives Alternatives

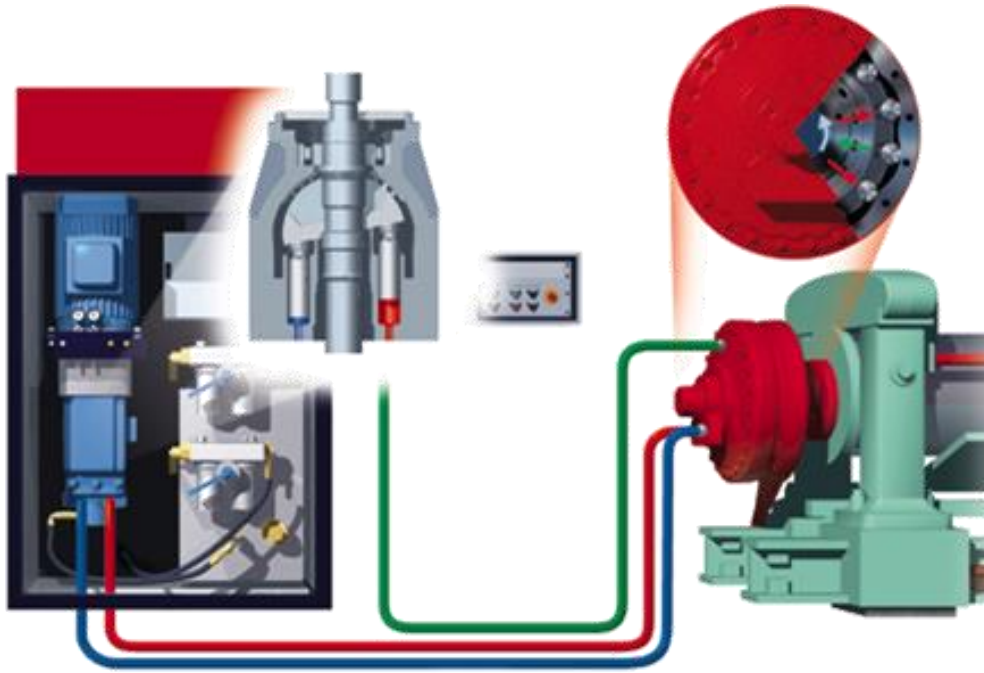
1. DC drives with variable speed inverter and gear reducers
2. AC drives with variable speed control unit and gear reducers
3. Direct Hydraulic drives
4. Hydraulic Drive with gear reducers



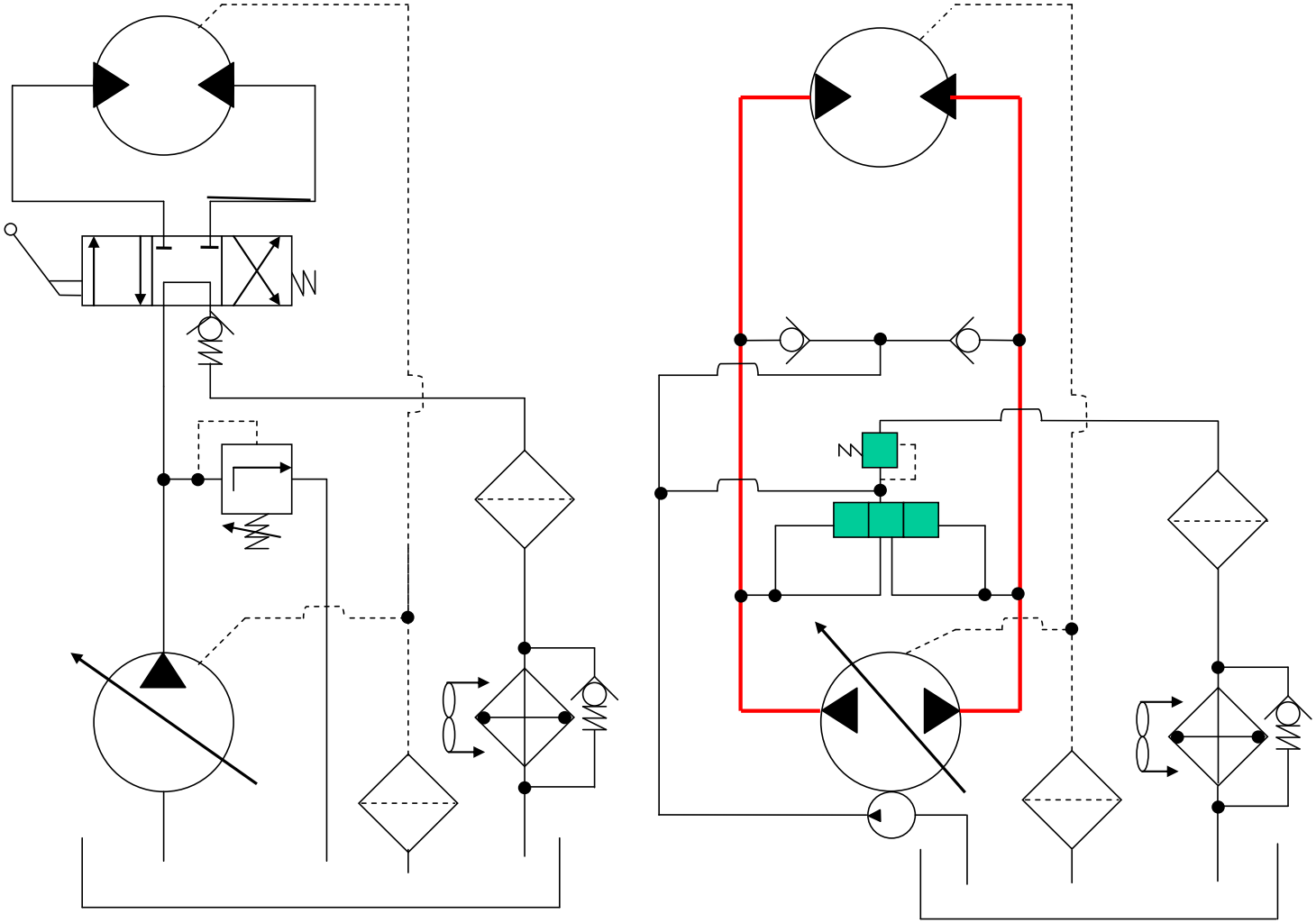
Direct Hydraulic Drive

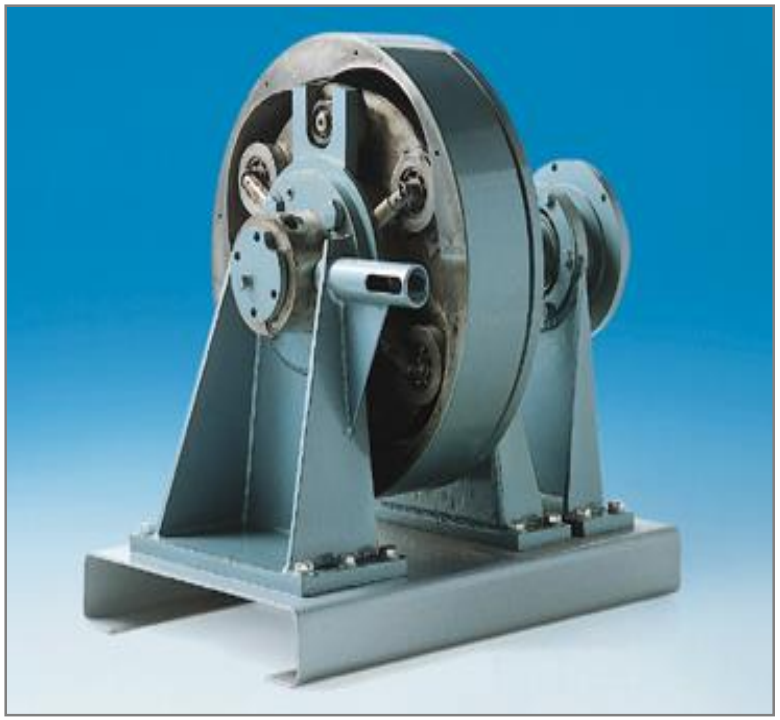
The Direct Hydraulic Drive consists of:

1. **LSHT hydraulic motor**
2. **Power unit**
3. **Pipes / flexible hoses**
4. **Electrical controls**

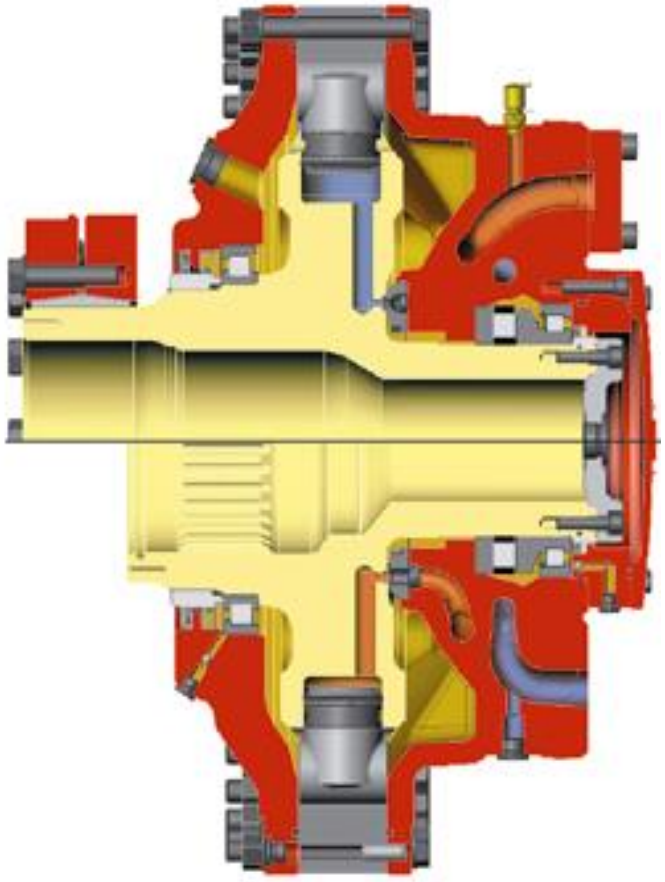


Open Loop & Closed Loop Circuit





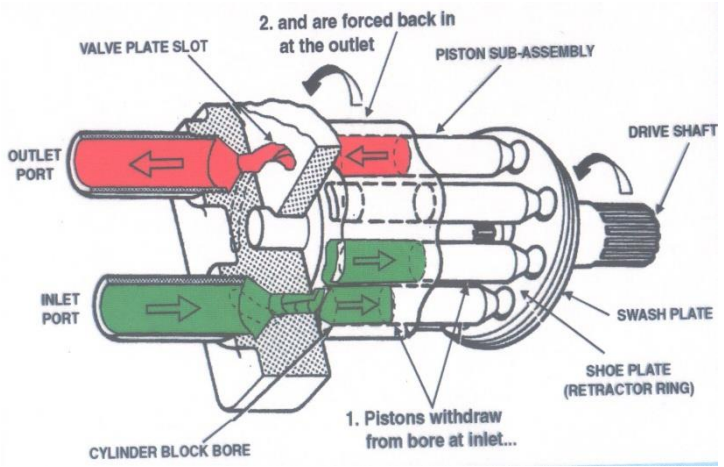
1957-Prototype L.S.H.T.

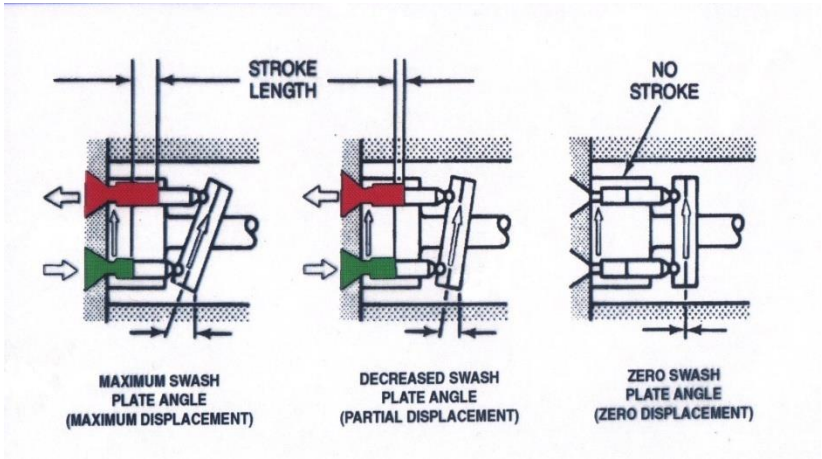


1994-L.S.H.T. Motor

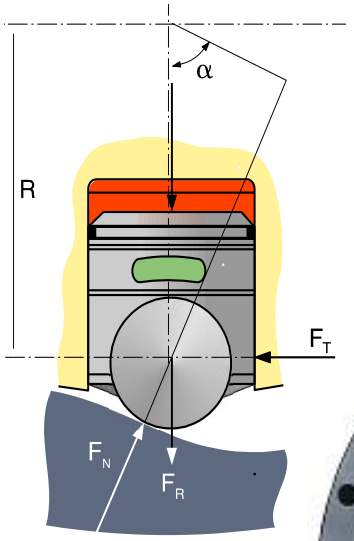
Variable displacement pump - function

- The pump displacement is dictated by an electrical signal
- The pump flow is controlled by the angle of the swash plate





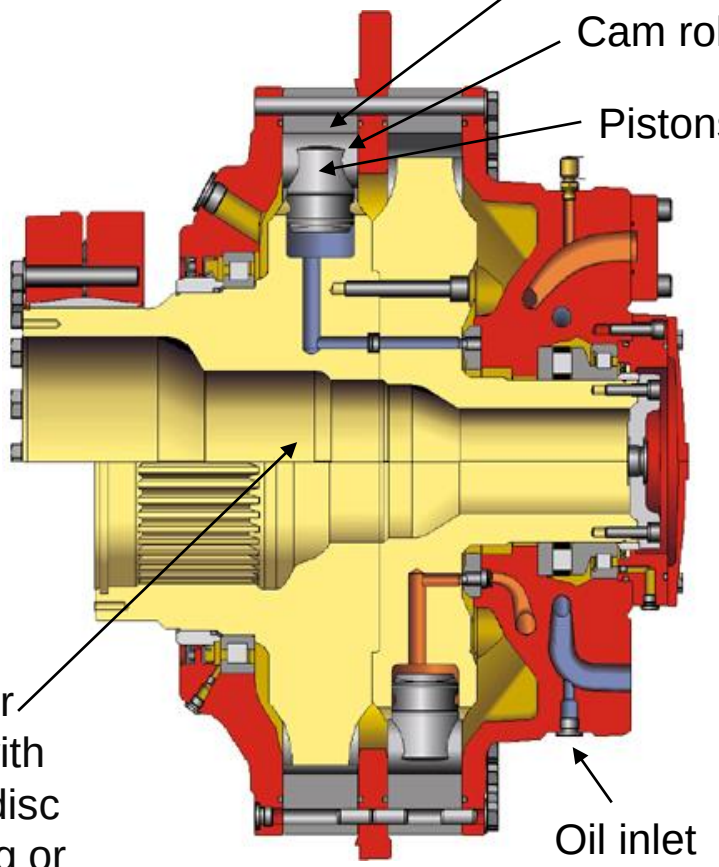
Operating Principle



$$F_T = F_R \times \tan \alpha$$

$$T = F_T \times R$$

F_R = *Piston force*
F_N = *Normal force*
F_T = *Tangential force*
T = *Torque*



Hydraulic power unit

The power unit supplies fluid to the motor. It is a closed loop hydraulic system

The hydraulic power unit consists of:

- **Electric motor, fixed speed**
- **Variable displacement pump**
- **Stainless steel tank**
- **Air or water/oil cooler**
- **Filters & Gauges**
- **Sound insulated cabinet**
- **Control / Monitoring Box**

Continuous development of DHD

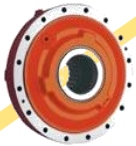
1960

130 RPM, 110000 Ft-Lbf

1983-1991

130 RPM, 1000,000 Ft-Lbf

System,
Power Unit 1985



1994

400 RPM, 51000 Ft-Lbf

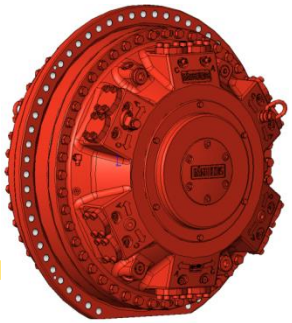
Control system,
1996

2002

100 RPM, 206,500 Ft-Lbf

2005

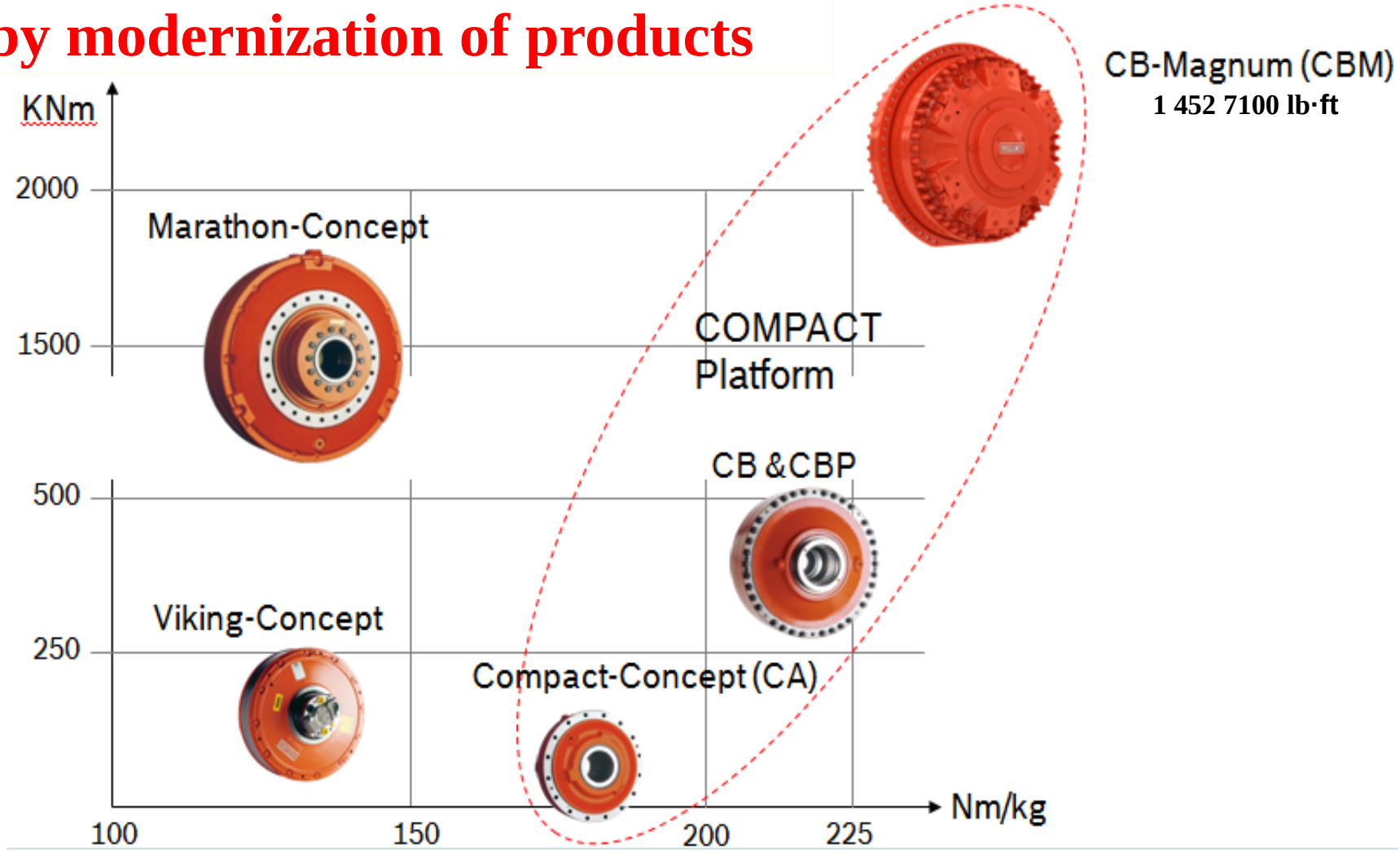
320 RPM,206,500 Ft-Lbf



2012

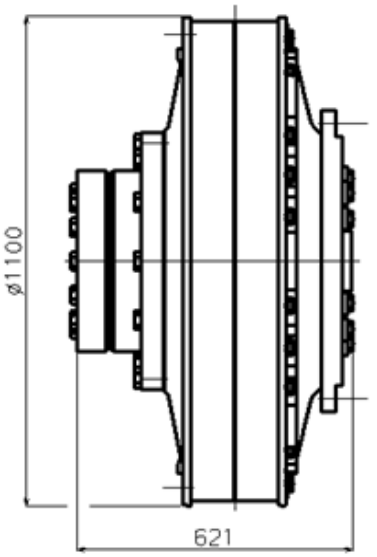
1,500,000 Ft-Lbf

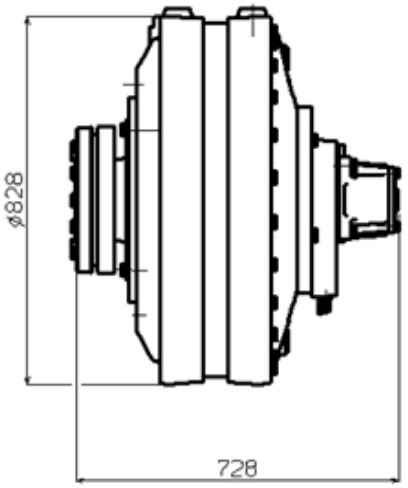
Increased Power density by modernization of products

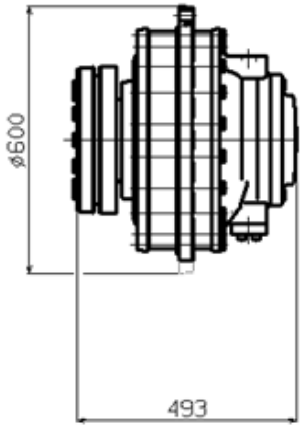


Technologies from 1991 to 2012-Increased Power density

L_{10ooh} = 20 000 h
T = 25 000 Nm
n = 25 rpm

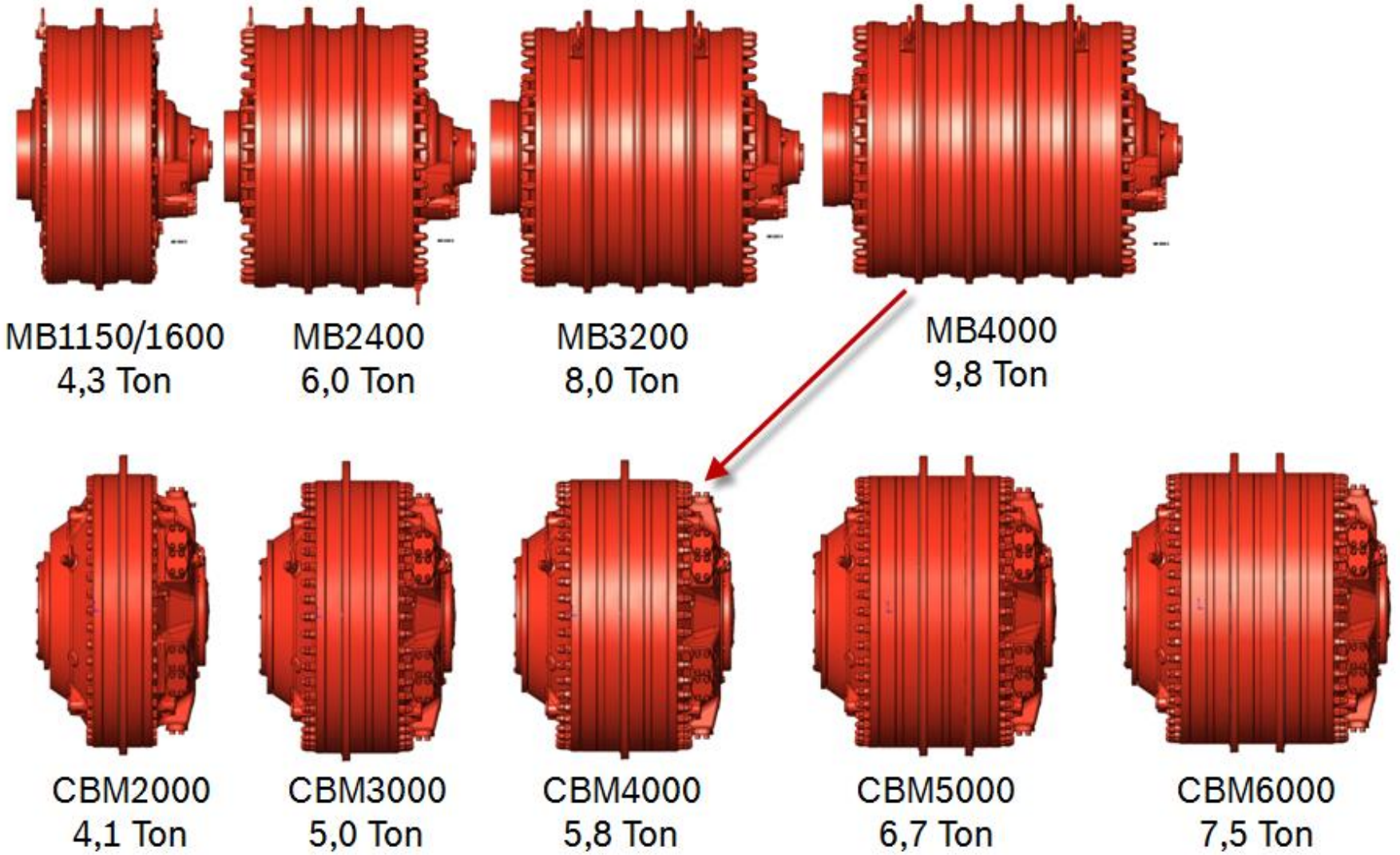






	VIKING 84-ser	MARATHON MA141	COMPACT CA140
In production year:	1972	1983	1994
Relative weight:	100 %	57 %	20 %
Power density:	0,3 KW/Kg	0,4 KW/Kg	2,5 KW/Kg

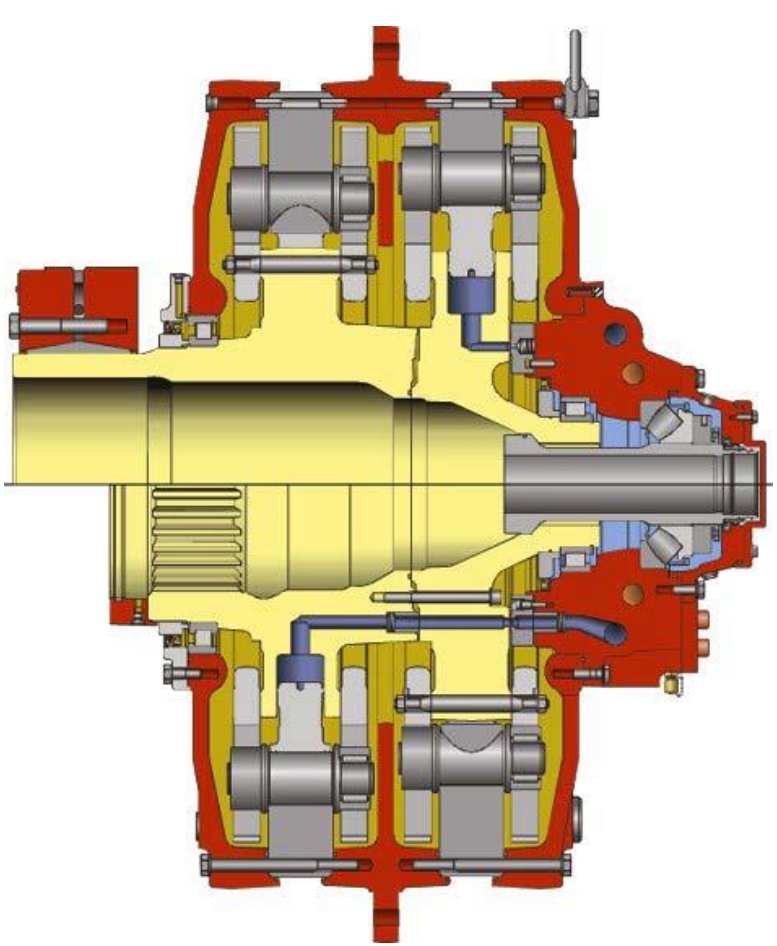
Technologies from 1991 to 2012-Increased Power density

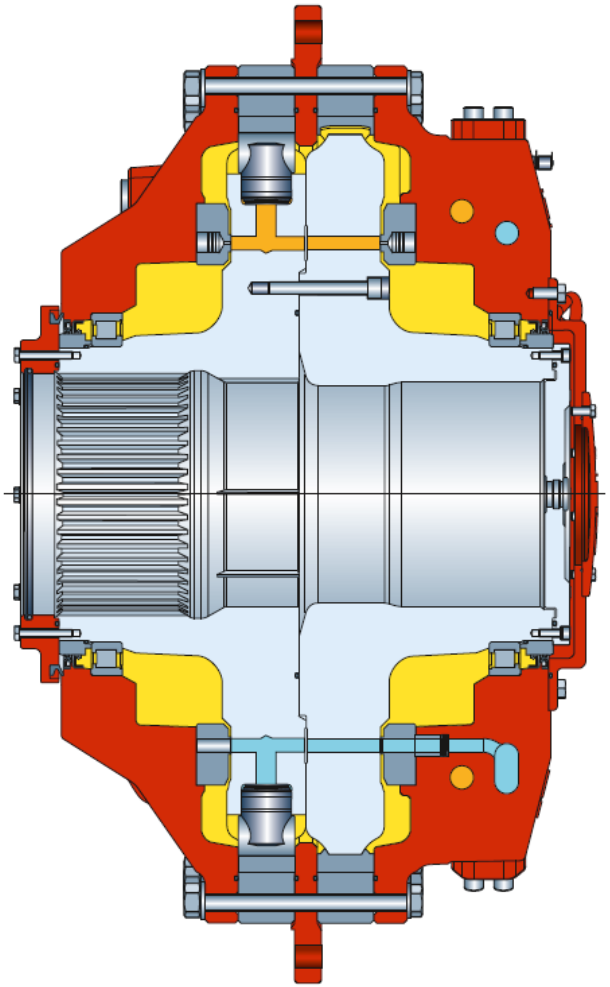


Technologies from yesterday to today

Increased Power density

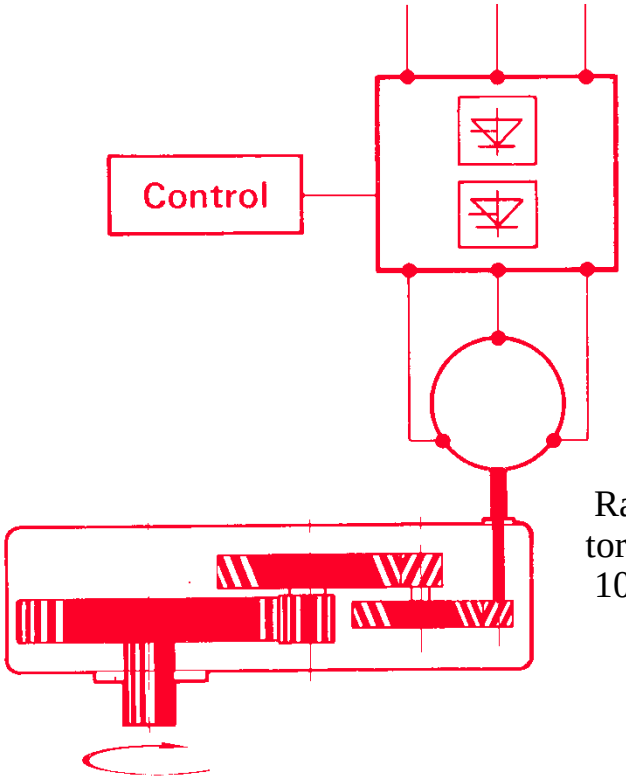
Yesterday **to** **today**

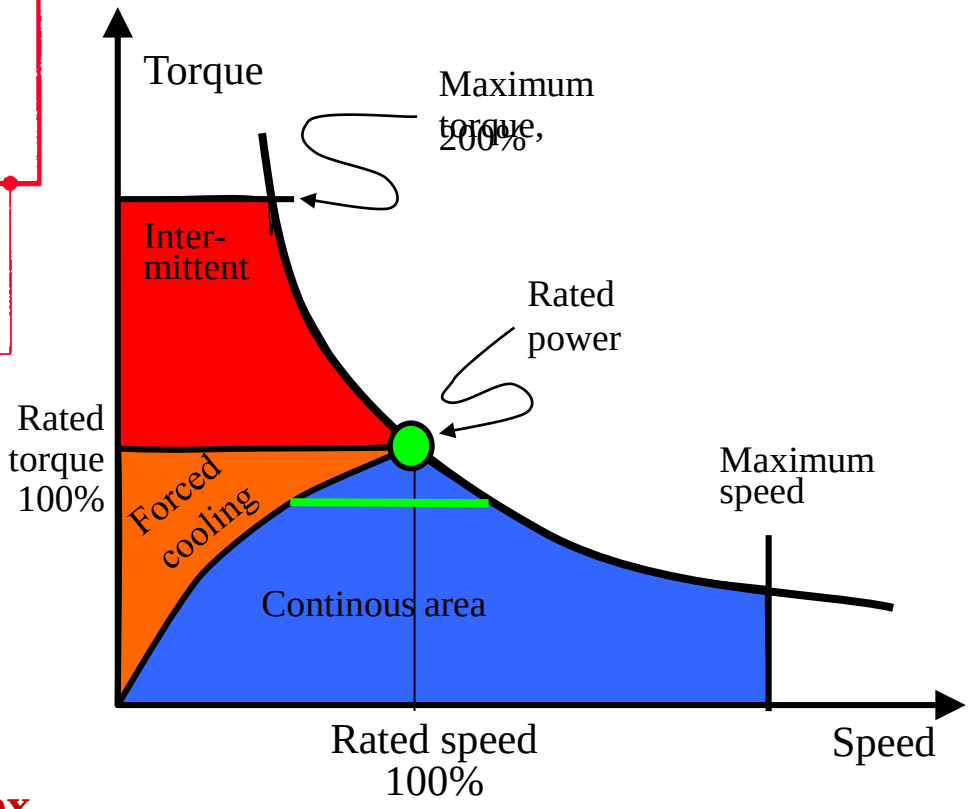




Comparison of Variable Speed Drives

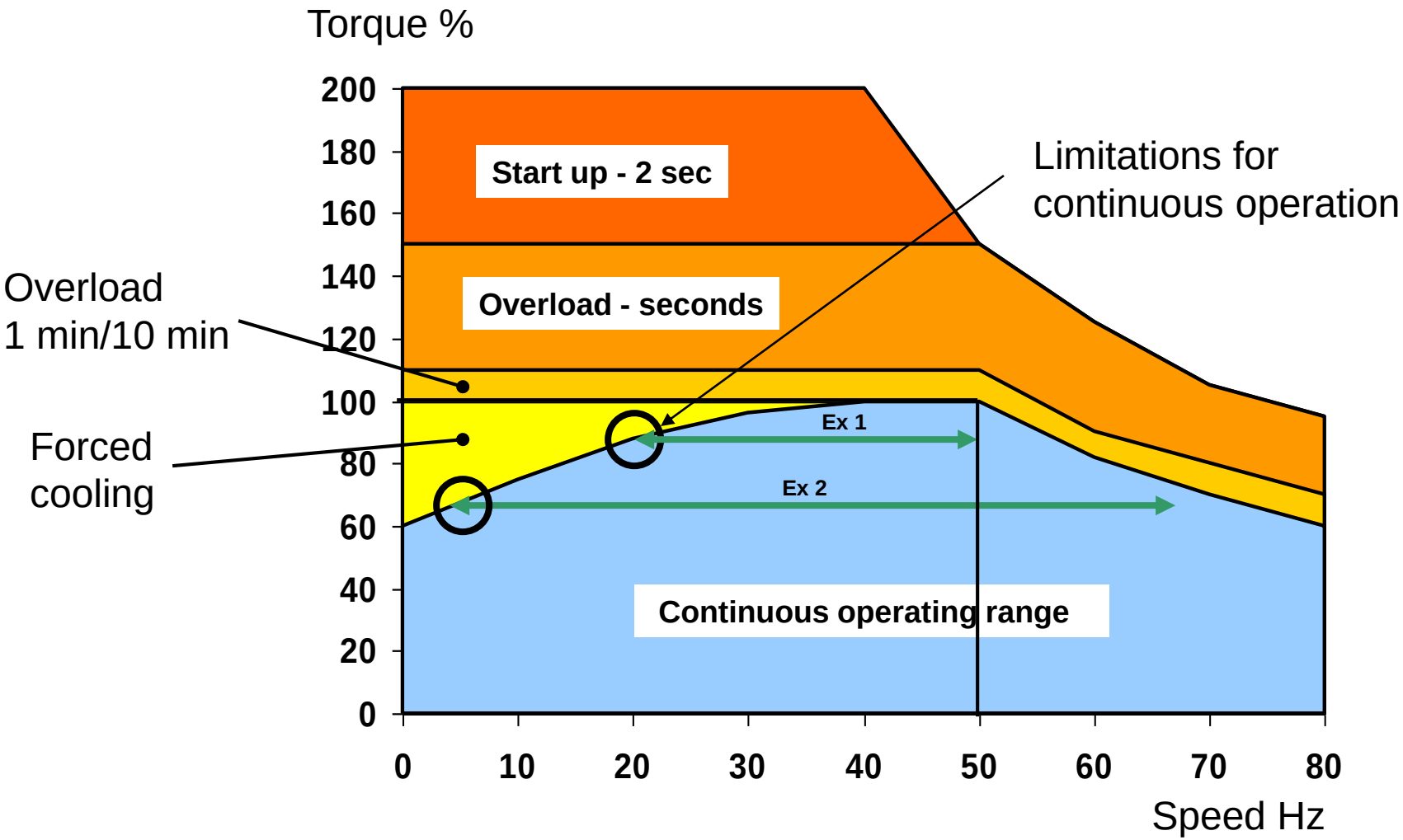
DC Drives performance



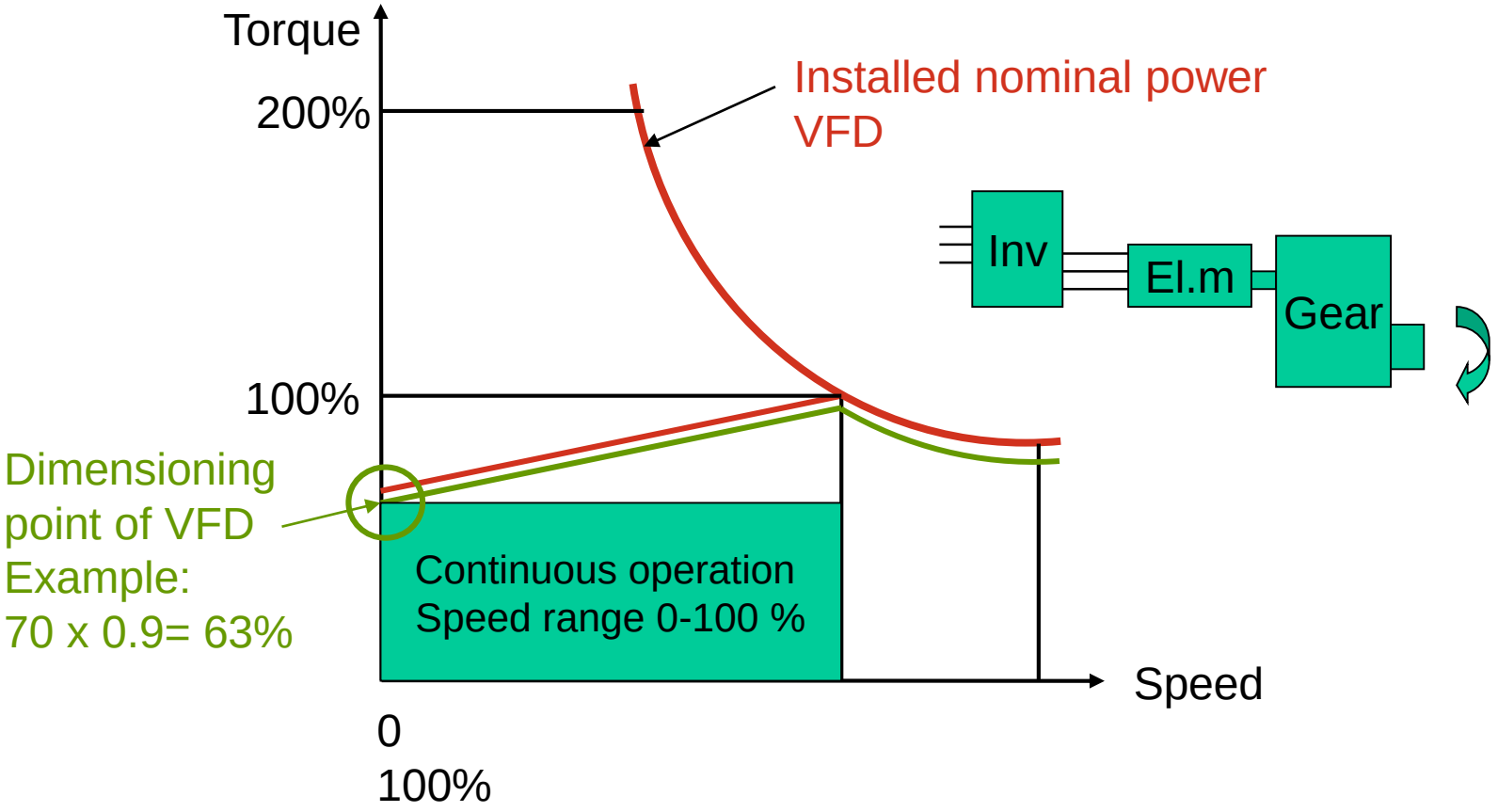


Electric motor with gearbox

VFAC Drives performance

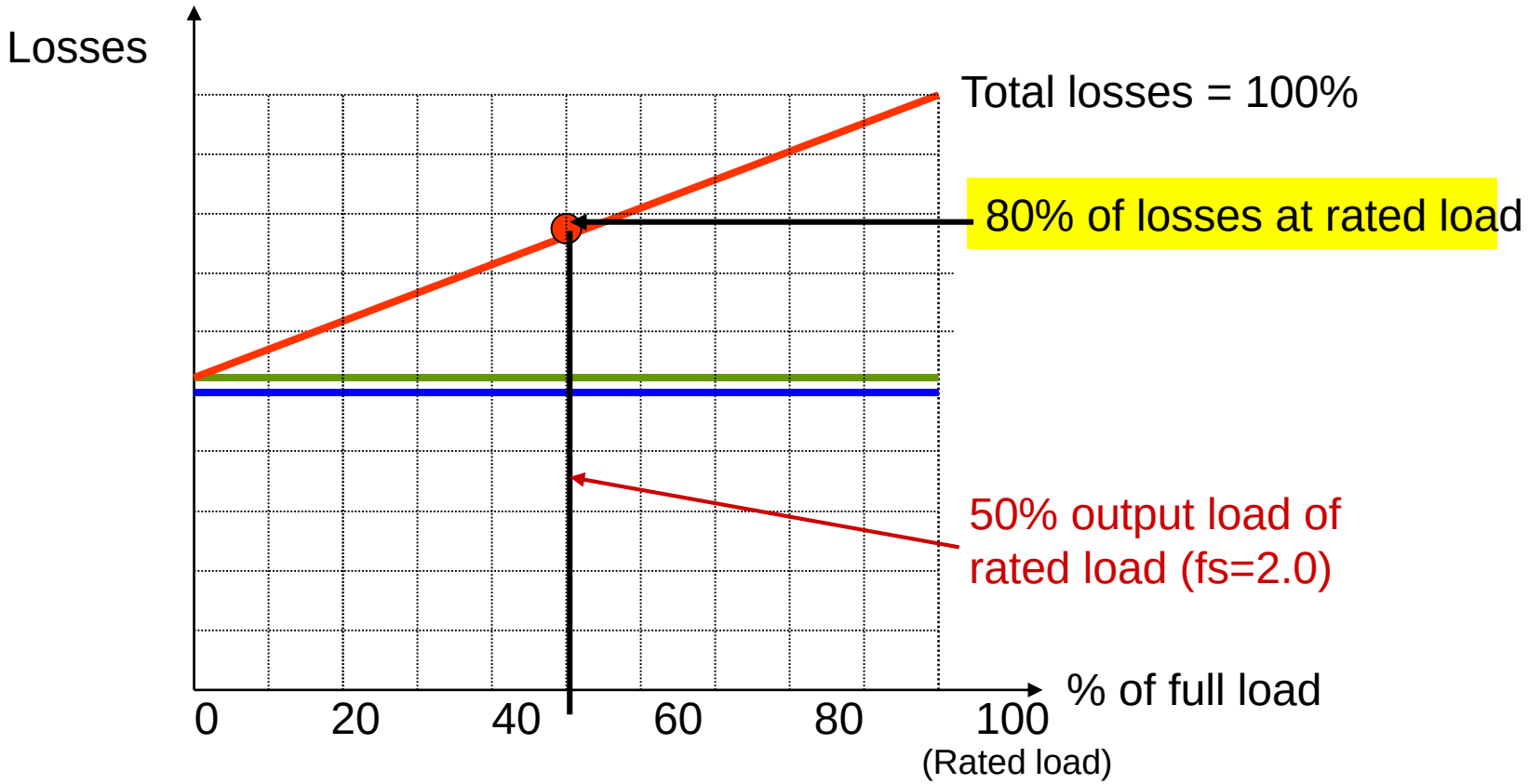


Continuous output torque – VFD drive

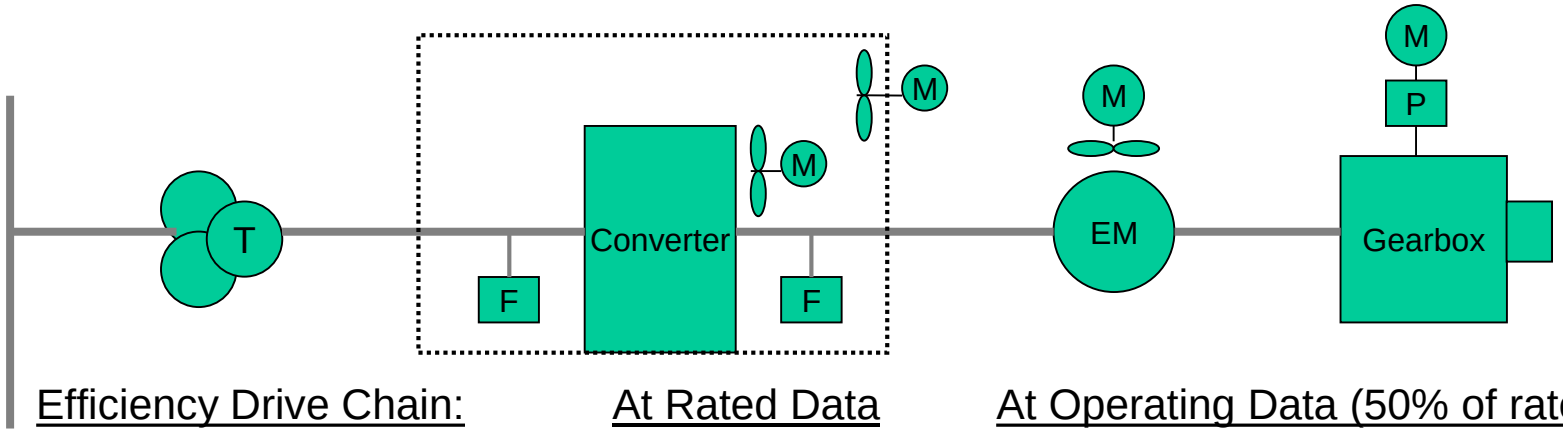


Losses in a 3-stage gearbox

Example; at 50% load and fixed speed



Overall efficiency VFD drive



Efficiency Drive Chain:	At Rated Data	At Operating Data (50% of rated)
Converter	97-98%	96-97%
Electrical motor	95-96%	94-95%
Gearbox 3-stage planetary, helical)	91-96%	87-93% (depends of gearbox,
	84-90%	**79-86%**
Additional Power consumption:		
Cooling & lubrication gearbox		98-99%
Forced cooling electrical motor		98-99%
Cooling Converter		99%
Cooling Converter room		97-98%
	Summary:	**73-82%**

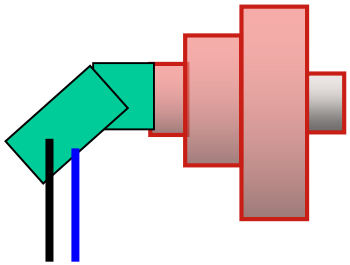
Losses caused by harmonic distortion:

Electrical motor, cables, electrical filters, transformer 95-99%?

Overall efficiency: 70-82%

Overall Efficiency

Hydraulic motor + planetary gearbox versus Direct Hydraulic Drive

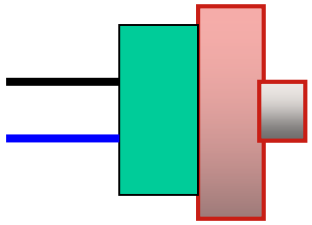


High speed motor + planetary gear

$\eta_{total\ motor}$ = 93%

$\eta_{total\ gear}$ = 91% (3-stage at rated data)

η_{total} = 85% (at rated data for gearbox)

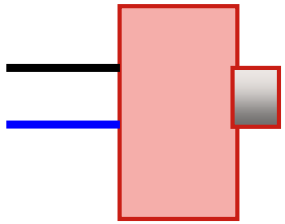


Medium speed motor + planetary gear

$\eta_{total\ motor}$ = 93%

$\eta_{total\ gear}$ = 97% (1-stage at rated data)

η_{total} = 90% (at rated data for gearbox)



Hydraulic Direct Drive

$\eta_{total\ motor}$ = 95-96%

Service life

Bearing rated life according to ISO 281

1962: Basic rating life, L10h:	Operating conditions has **not** been taken into account
1977: Adjusted rating life, L10ah:	Lubrication conditions has been taken into account
2000: Modified rating life, L10aah:	Lubrication conditions, fatigue limit and contamination has been taken into account. (SKF use this theory since 1989).

Service life of a Gearbox

The service life depends of;

- Type of application
- Service factor
- Thermal rating of gearbox
- Oil temperature and viscosity
- Cleanliness of oil
- Water content in oil
- Wear

Service life of a Hydraulic Drive

The service life depends on;

- Torque/pressure and speed
- Oil temperature and viscosity
- Cleanliness of oil
- Water content in oil
- Wear

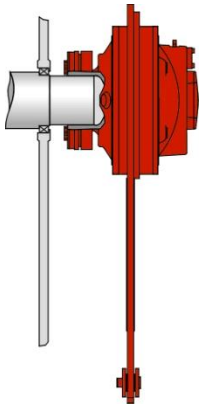
Comparison of service life

- Service life of LSHT motors are based on **L_{10ah} or L_{10aah}**
- Service life of gearboxes are normally based on **L_{10}**
- The gearbox **L_{10}** and Hägglunds **L_{10aah}** can not be compared to each other as reduction factors according to ISO 281 not are used in the gearbox **L_{10}** calculation

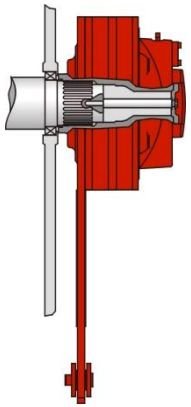
Features of Direct Hydraulic Drive

Versatile mounting, *Possibilities to optimize the machine design*

Torque arm mounted motor

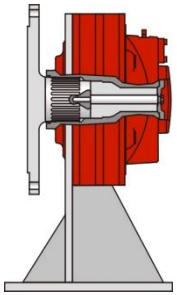


With shrink disc coupling.

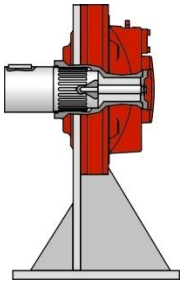


With splines.

Bracket mounted motor

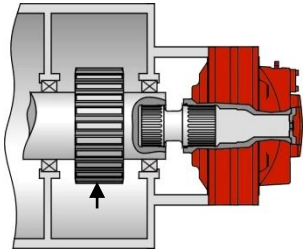


With flange adapter.

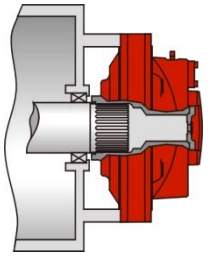


With stub shaft.

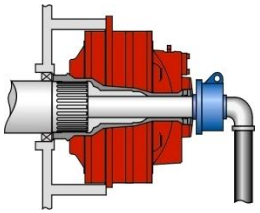
Flange mounted motors with splines



High radial load (Fr) on driven shaft.



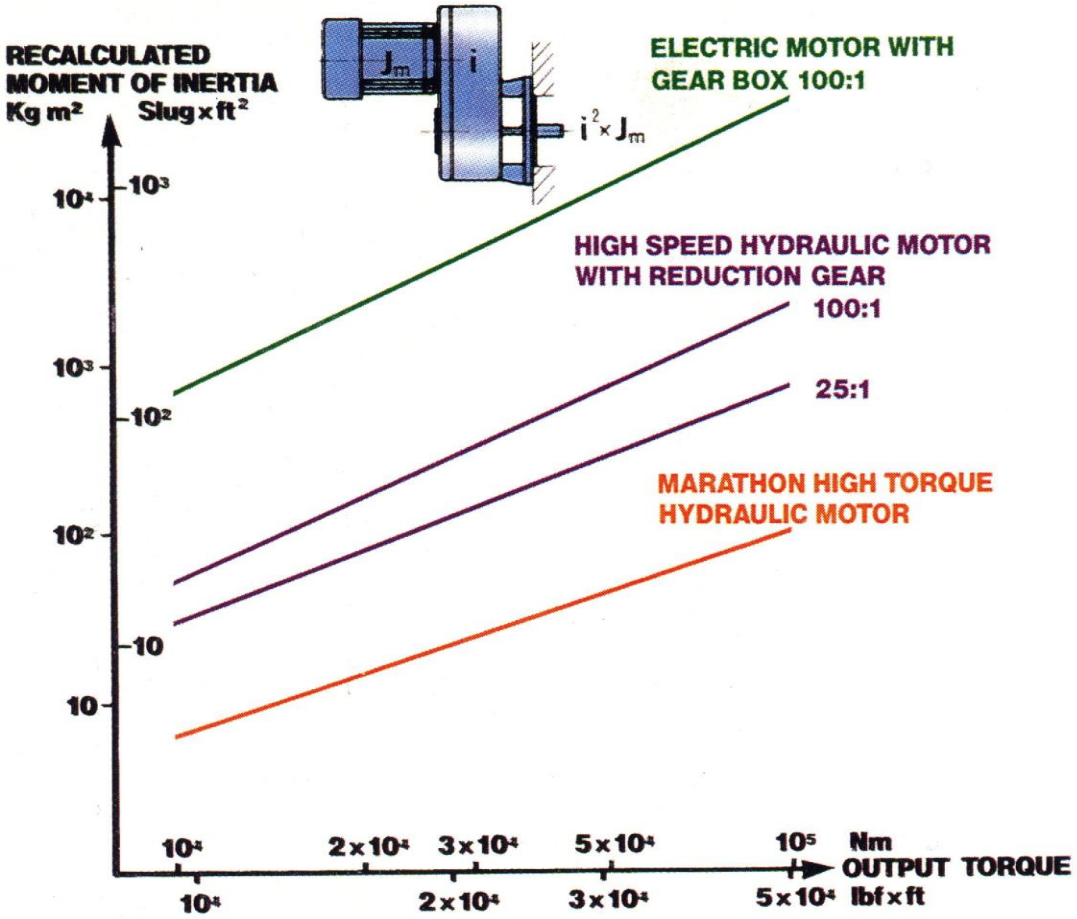
Low radial load on driven shaft.



Through hole for cooling of driven machine.

Features of Direct Hydraulic Drive

Low Moment of Inertia for the Drive



A hydraulic direct drive has less than 1 % of the moment of inertia on an equivalent Electro-mechanical drive

Calculation example; Hydraulic Direct Drive

Torque generated by the LSHT hydraulic motor:

$$T = 18.3 \times \frac{2\pi \times 1470}{60 \times 0.083} = 462 \text{ Nm (driven shaft)}$$

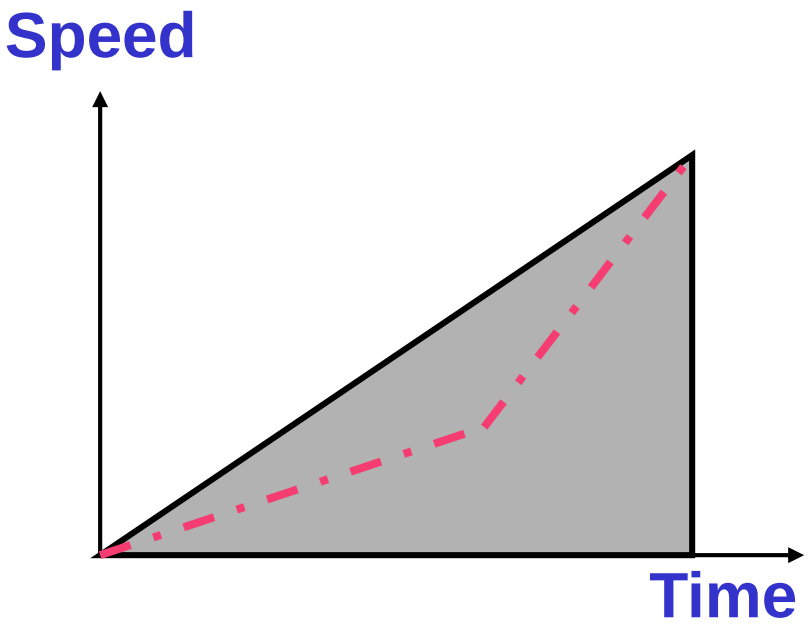
Torque generated by the Moment of Inertia of the hydraulic motor is **only 0.7%** of the hydraulic motor rated torque (70000 Nm).

The supplementary stresses caused by the Moment of Inertia of the drive motor are **813 times** higher for an Electrical motor with a gearbox compared to a Hydraulic Direct Drive!

Features of Direct Hydraulic Drive

Soft start

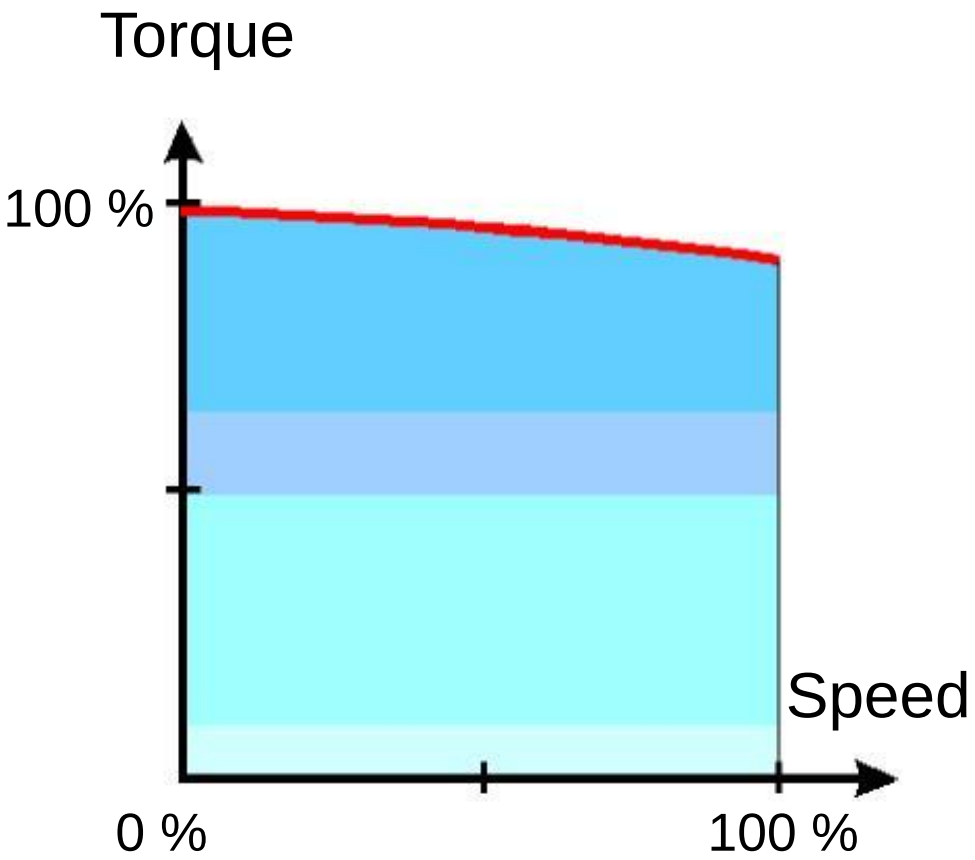
- Step less Acceleration and Deceleration
- Soft start, reducing the stresses on the driven equipments



Features of Direct Hydraulic Drive

Accurate torque response

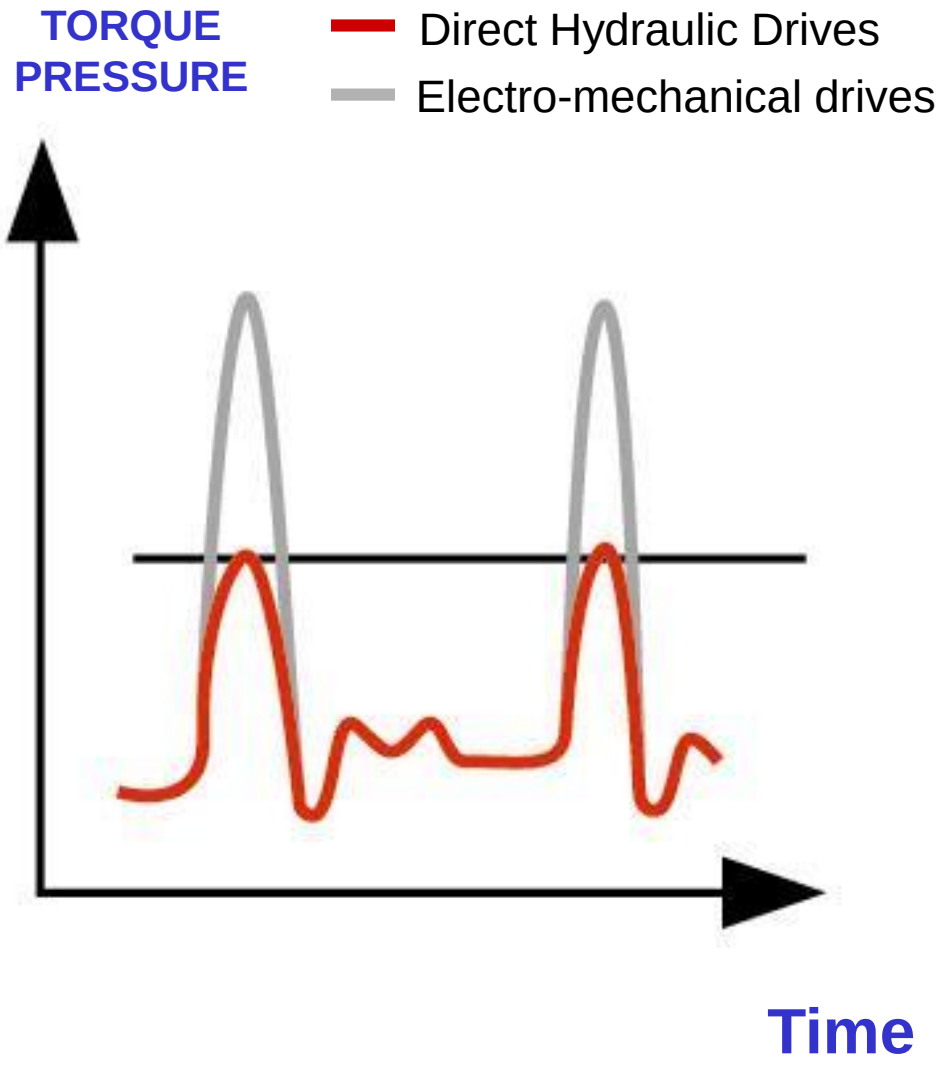
- The Hydraulic Drive can operate at nearly constant torque throughout the speed range
- The Hydraulic Drive can accurately limit the maximum torque of the system.



Features of Direct Hydraulic Drive

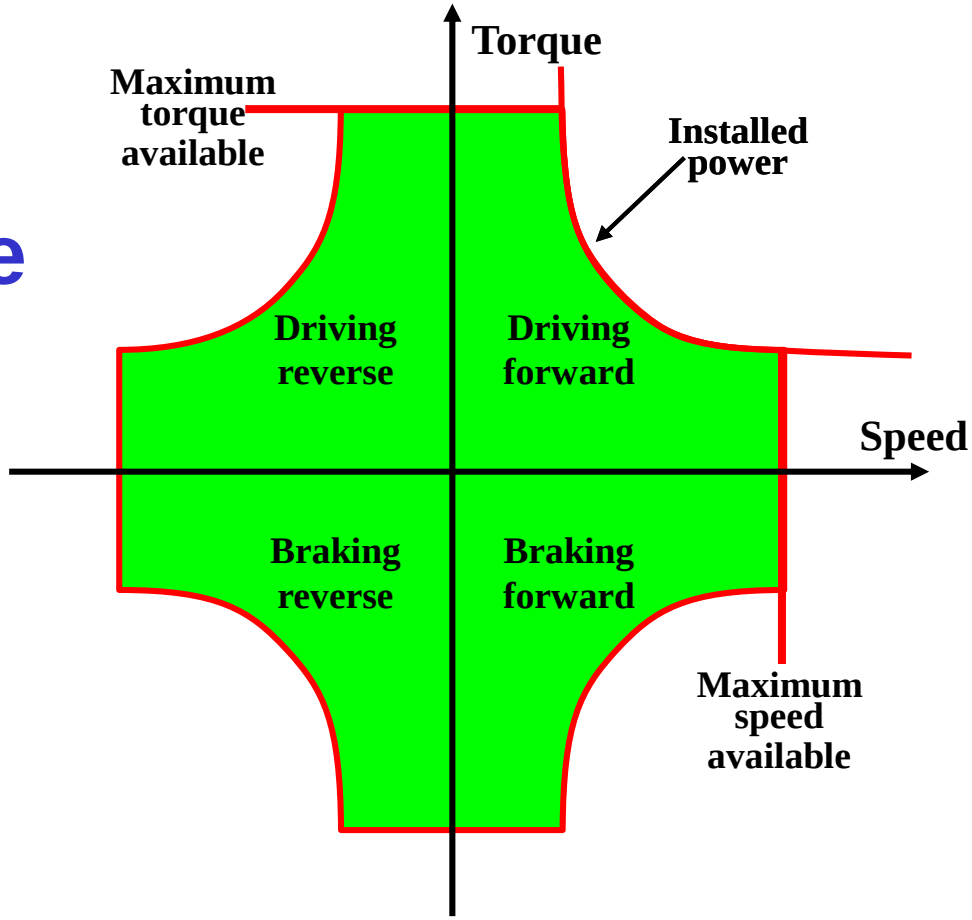
Shock load protection

- The low inertia ensures that the maximum torque is not exceeded
- Peak loads are limited by the fast acting pressure limitation in the system



Features of Direct Hydraulic Drive

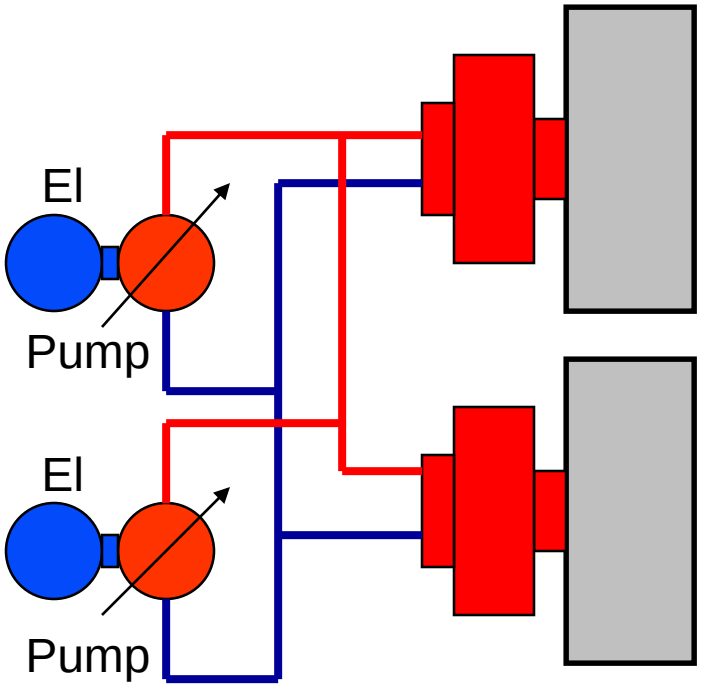
Four Quadrant drive



Features of Direct Hydraulic Drive

Load sharing

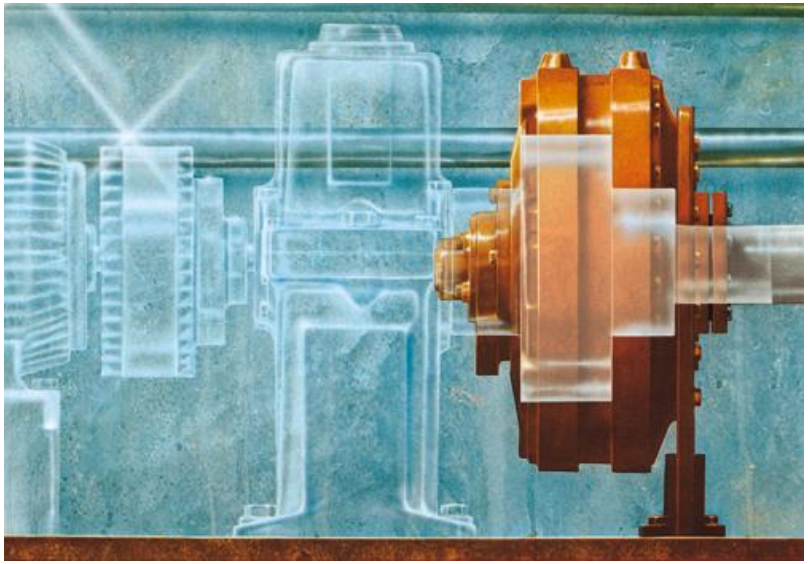
- The hydraulic motors are supplied from a common hydraulic system
- Load is balanced by fluid pressure
- Multiple pumps or motors provides flexible combination.



Features of Direct Hydraulic Drive

Weight reduction

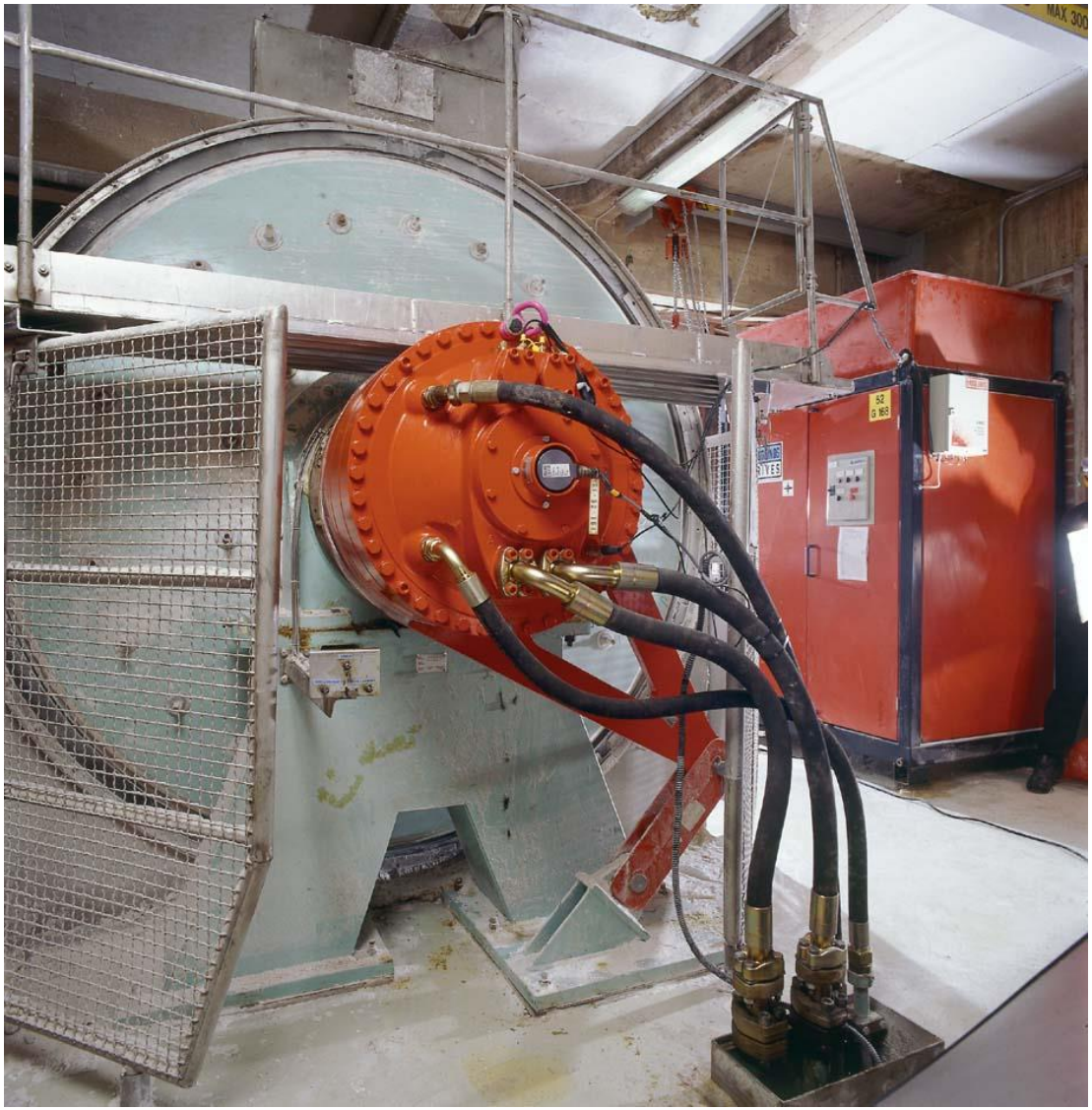
- The Hydraulic motor has much less weight than an equivalent Electro-mechanical drive solution
- The power pack can be installed remotely from the motor
- Less weight of the drive means reduced stress on the boom



Features of Direct Hydraulic Drive

Unlimited starts & stops without any problems.

Features of Direct Hydraulic Drive

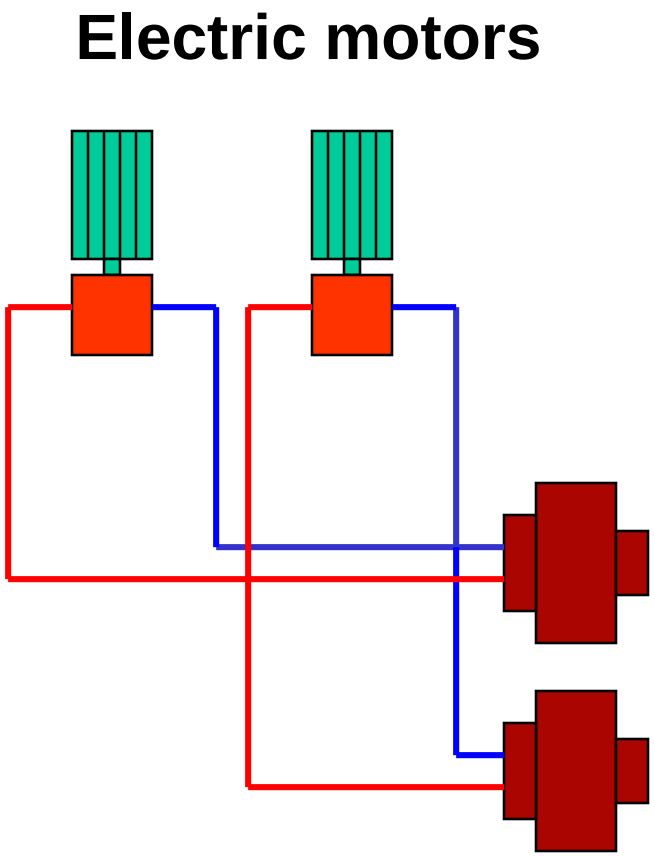


Space saving & Simple to install

Features of Direct Hydraulic Drive

Reduced electrical load

- Stops & starts can be achieved without effecting E motor status
- Each E motor starts in turn in an unloaded condition (pumps at zero)
- Modular Concept –Use of LT Motors in place of HT
- Great flexibility - reduced starting current requirement

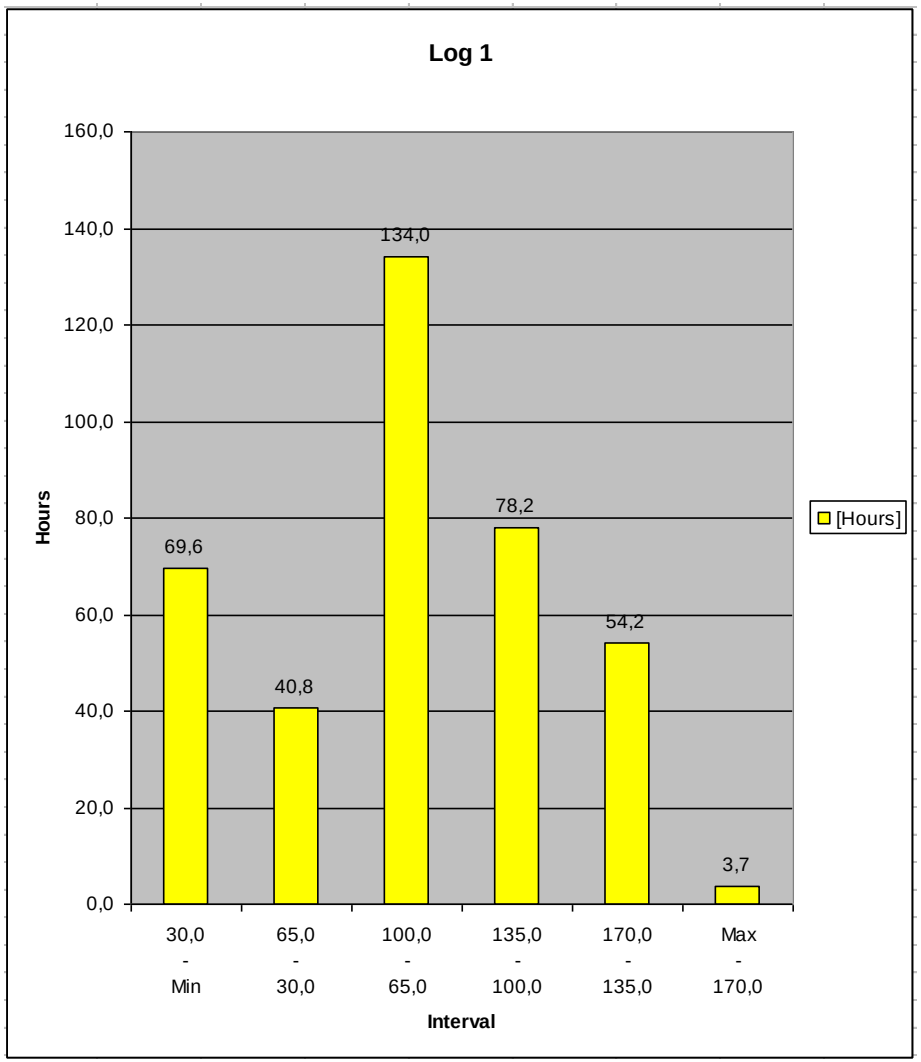


Drive Log Data for DHD

Shows how long time a pre-set parameter have been within two limit values

Selectable log channel readings:

- Speed
- Pressure
- E-motor power
- Temperature
- Speed set point
- System internal signals
  (stroke current, error signal etc.)



Drive Log from Control Box

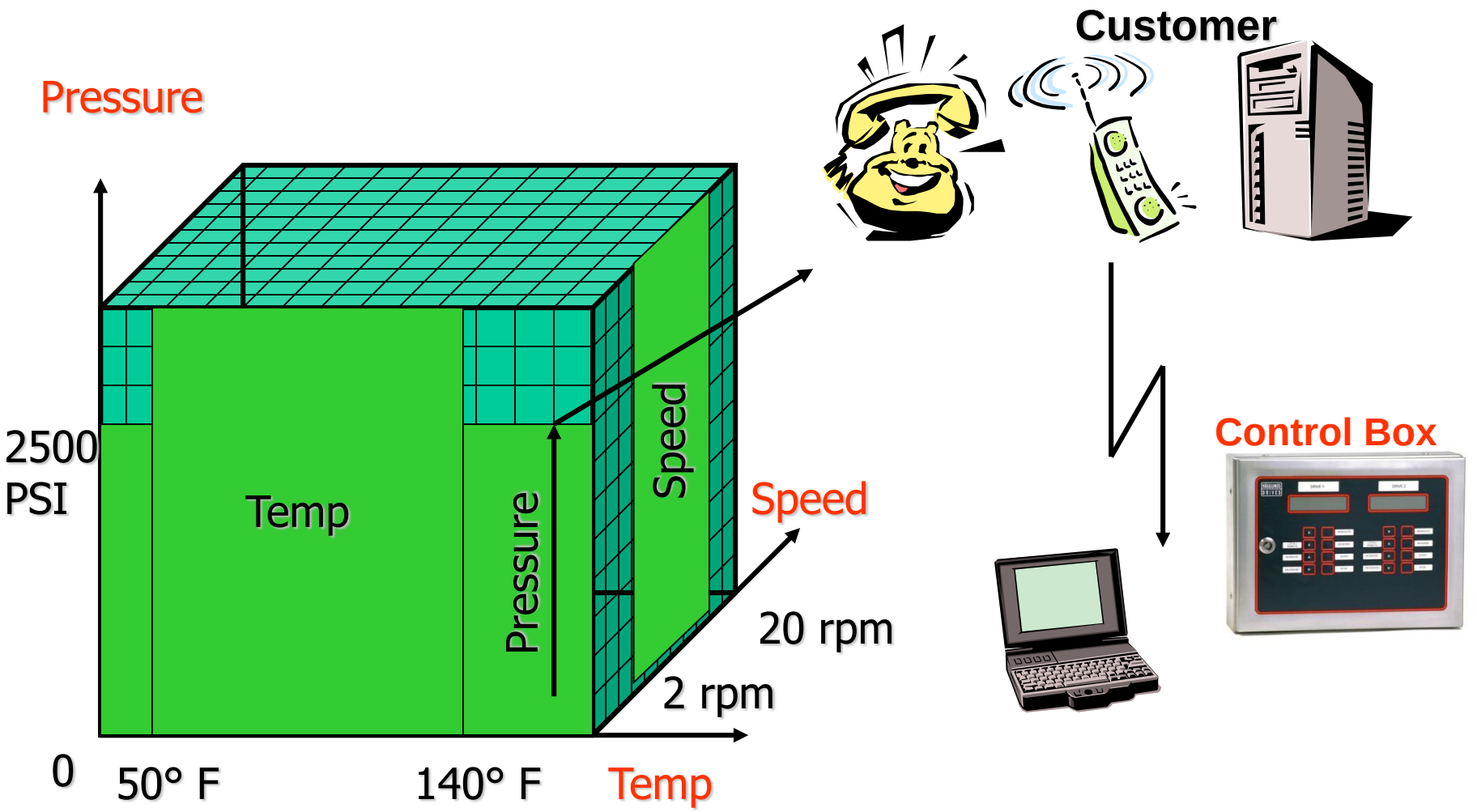
Alarm Drive 1		
1	000211 07:38	MAX TEMP
2	000211 07:38	SUCTION LINE
3	000211 07:38	CHARGE PRESSURE
4	000211 07:38	MIN OIL LEVEL
5	000128 14:06	CHARGE PRESSURE
6	000128 14:06	MIN OIL LEVEL
7	000126 13:39	CHARGE PRESSURE
8	000126 13:39	MAX TEMP
9	000126 13:39	MIN OIL LEVEL
10	000126 13:39	SUCTION LINE

Alarm Drive 2		
1	000211 07:38	MAX TEMP
2	000211 07:38	MIN OIL LEVEL
3	000128 14:06	MIN OIL LEVEL
4	000126 13:39	MAX TEMP
5	000126 13:39	MIN OIL LEVEL
6	991214 10:57	MAX TEMP
7	991214 10:57	MIN OIL LEVEL
8	991214 07:48	MAX TEMP
9	991214 07:48	MIN OIL LEVEL
10	0	0

Warning Drive 1		
1	000211 07:38	RETURN FILTER
2	000211 07:38	DRAIN FILTER
3	000211 07:38	LOW OIL LEVEL
4	000126 13:39	DRAIN FILTER
5	000126 13:39	RETURN FILTER
6	000126 13:39	LOW OIL LEVEL
7	991214 10:57	LOW OIL LEVEL
8	991214 07:48	DRAIN FILTER
9	991214 07:48	RETURN FILTER
10	991214 07:48	LOW OIL LEVEL

Warning Drive 2		
1	000211 07:38	DRAIN FILTER
2	000211 07:38	LOW OIL LEVEL
3	000126 13:39	DRAIN FILTER
4	000126 13:39	LOW OIL LEVEL
5	991214 10:57	LOW OIL LEVEL
6	991214 07:48	DRAIN FILTER
7	991214 07:48	LOW OIL LEVEL
8	0	0
9	0	0
10	0	0

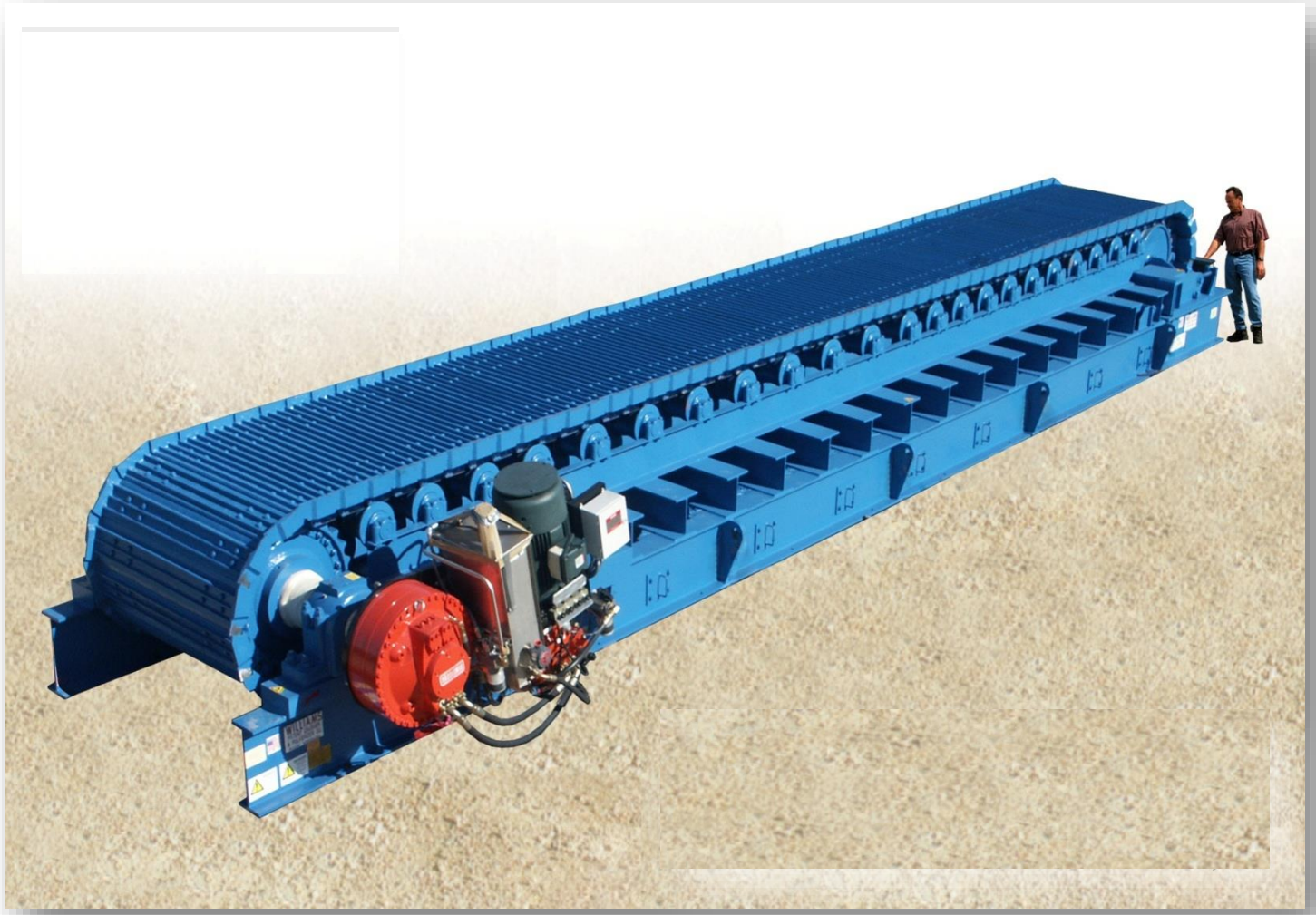
Remote Logging & Monitoring System
Early Warning Prediction



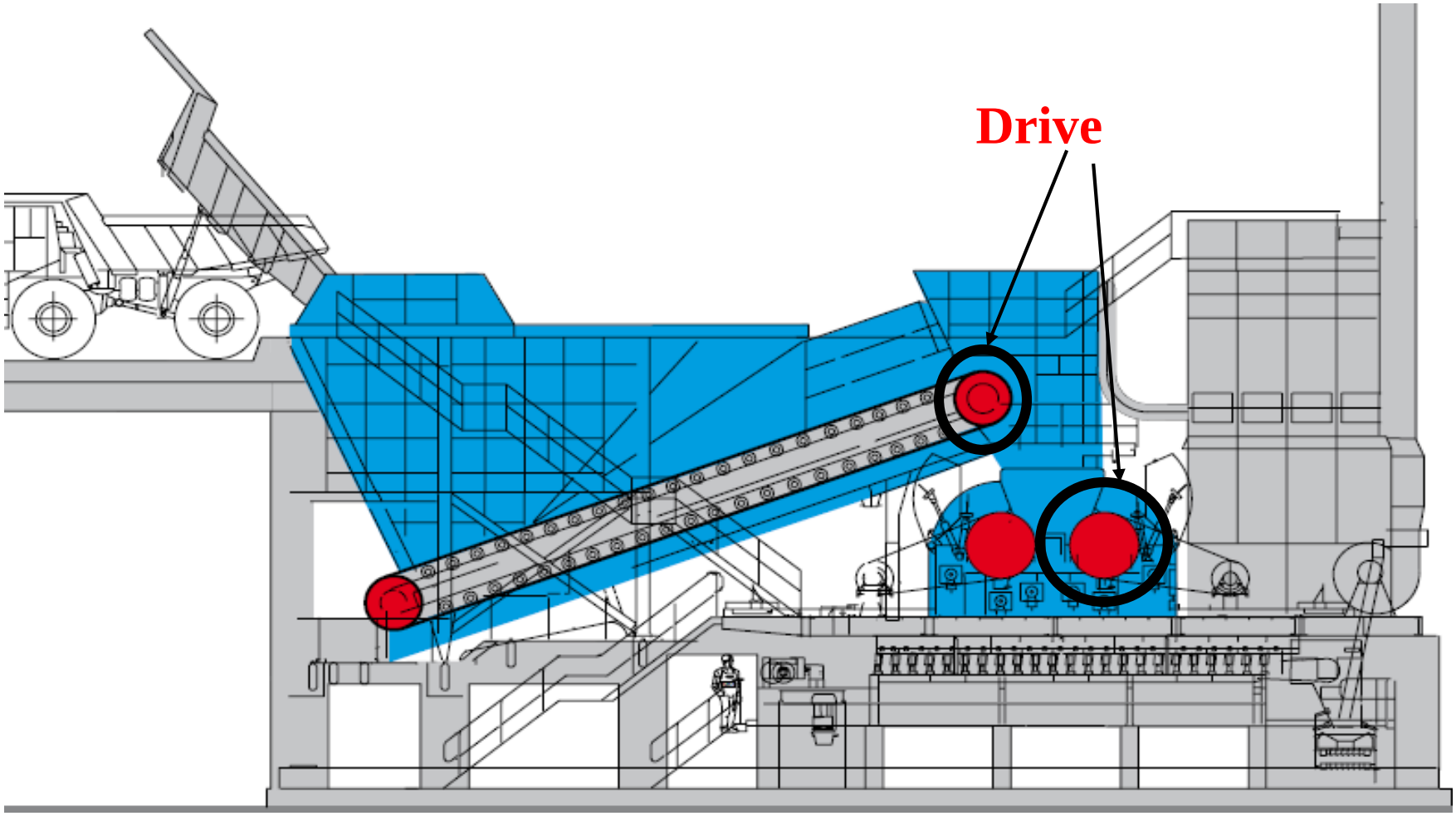
Self Contained-TADS Torque Arm Drive Systems

For Low speed Low power Below 125 HP

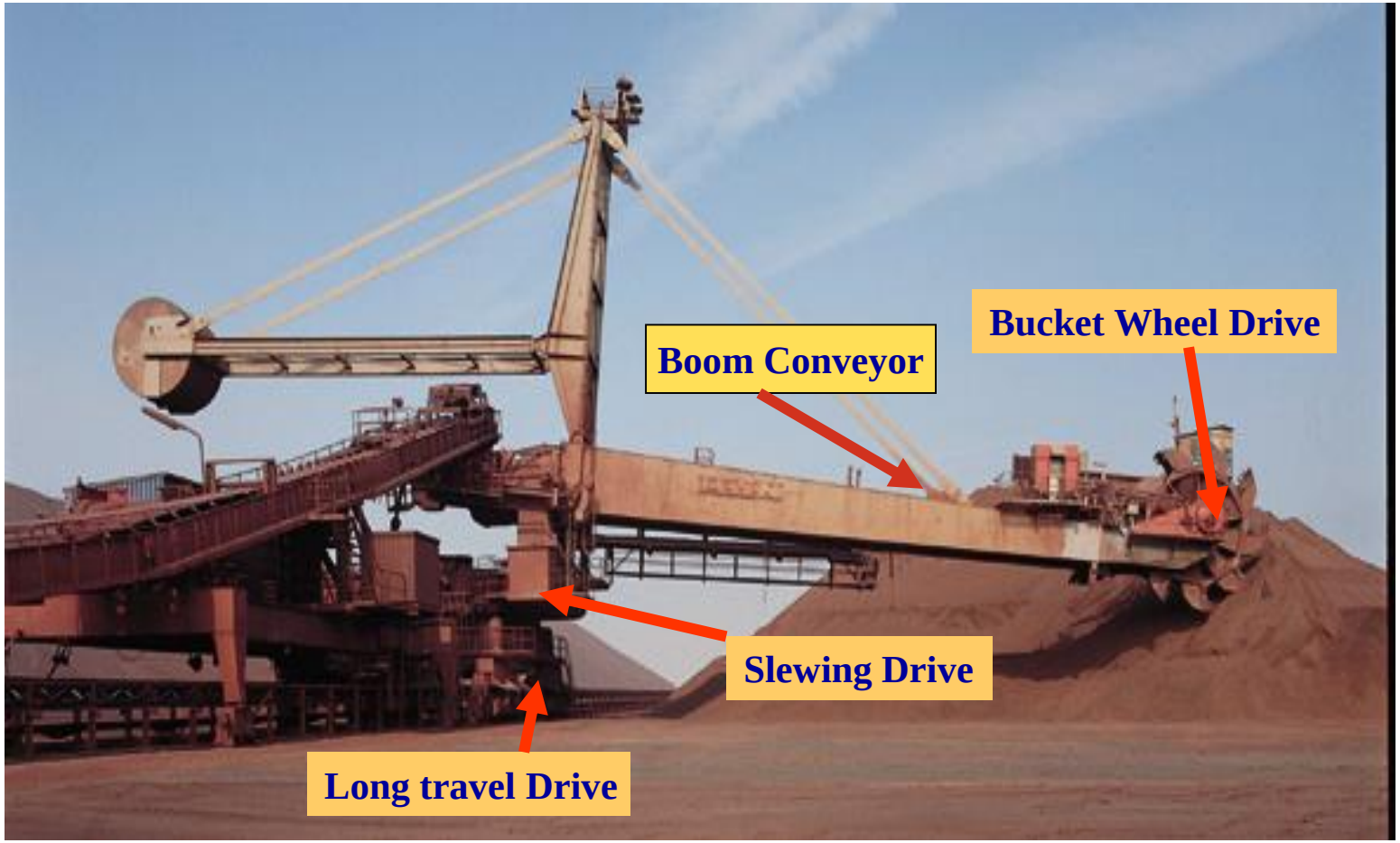
Torque Arm Drive System for Feeders
Self Contained Complete drive
100,000 Ft-Lbf, 75 Hp, 0-8 RPM



Typical apron feeder & Two roll crusher installation



Applications for DHD, BWR



Slewing Drive for BWR Drives

Power PLANT Coal blending Conveyor Drives

Screw Feeder Drive, for Bulk Material Handling

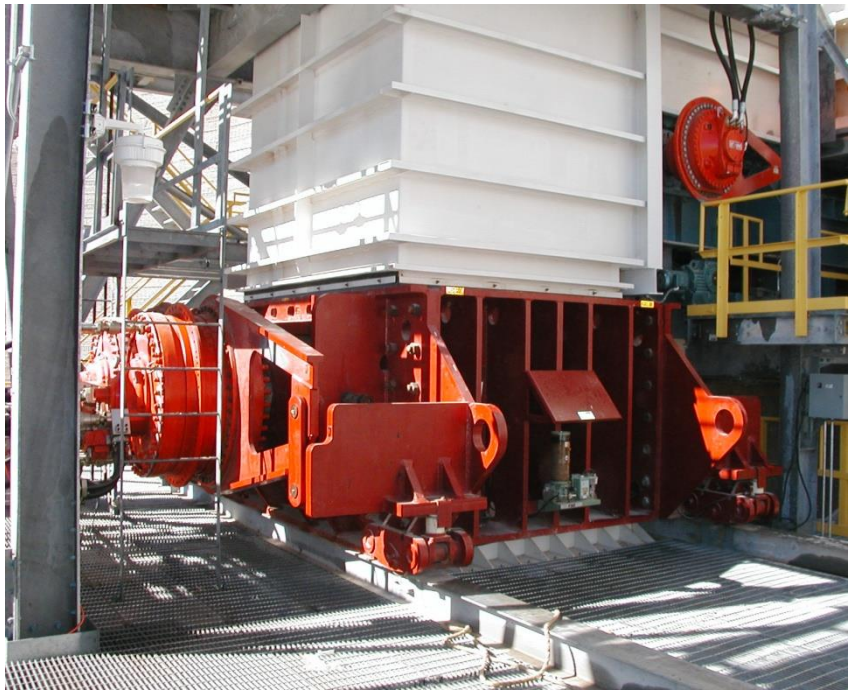
Belt Feeder – Collahausi Chile

Motor: 2 x CB 840
Power: 2 x 104 kW

Scrubber Drum drives 800 hp, 0-11 rpm 4400 TPH Limestone washing dirt

2 ROLL CRUSHER , Direct Drive

2 X LSHT DHD, 4 X 600 HP, 0 -27 RPM
4400 TPH.



Bucket Wheel Drive

Before
(Electro-Mech. Drive)

After
(Direct Hydraulic Drive)

Conveyor Drive Drive upto 3500 kW

Long Travel Drive for BWR

Before
(Electro-Mechanical Drive)

After
(Direct Hydraulic Drive)

Conclusion

- **Today's demanding mining industry can benefit from this Direct Hydraulic Drive DHD for following;**

1. **Apply the long term experience from Mining and material handling plants, ports and many industrial sectors like Pulp & Paper, Cement, Chemical, Rubber and so on**
2. **Improve reliability & productivity**
3. **Reduce down time, maintenance & life cycle cost.**
4. **Provide more flexibility for future expansion**

Where can we apply DHD ?

- Conveyor & Feeder Drives
- Bucket Wheel Reclaimers

Bucket Wheel Excavators

- Low speed crushers
- Wagon Tipplers & Side Arm Charger
- Drum & Kiln Drives
- Ball Mill Drives & Inching Drives
- Roller Mills & Pulverizers
- Surface Miners
- Thickeners
- Slewing

Thank You!

Questions ?

I will be also available throughout this conference and Exhibit hall area