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WELCOME TO

Webinar on Pumps & Circulators

Ecodesign & optimization of pump systems

December 17, 2015

Webinar on Pumps & Circulators

Agenda

- Ecodesign regulation on **Water pumps**
  - Savings potential, scope and type definitions
  - Ecodesign requirements & dates
  - Test method & test standards involved
  - Verification procedures and compliancy steps
- Ecodesign regulation on **Circulators**
  - Savings potential, scope and definitions
  - Ecodesign requirements & dates
  - Test method & test standards involved
  - Verification procedures and compliancy steps
- "Live session"
  - Calculation example by screen sharing, The MST-Tool
- Q&A, End of webinar

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Webinar on Pumps & Circulators

December 17, 2015 – Online, Internet

Sandie B. Nielsen (sbn@dti.dk)
– Danish Technological Institute

- **Electrical Engineer (1996) - Drives specialist, programmer**
- **Employments:**
  1996-2001 – ABB (Drives specialist)
  2001-2002 – DEFU (Multiple Energy Projects)
  2002- present:

  Danish Technological Institute
  - **Multiple Energy Projects**
  - **Technical consultant for Danish Energy Agency (ECO-design motors, pumps)**
  - **External Trainer at Grundfos A/S (pumps and pump applications)**
  - **DAQ software development**
  - **Head of accredited testing laboratories for motors, pumps & circulators**
  - **Task leader in EMSA since 2009**
  - **IEC TC22G WG18 member – Drives efficiency (Internationalization of EN 50598 series)**

Water pumps

Introduction

- Ecodesign regulation on water pumps was first decided and published in the Official Journal of the European Union in the summer of 2012 (No.: 547/2012)
  - Based on European preparatory study Lot 11, finished February 2008
- First tier came into force on January 1st, 2013, The second: January 1st, 2015
- Estimated annual energy savings of 3.3 TWh by 2020
  (Compared to no measures)
- This is a regulation focusing on the component!
  - Isolated efficiency requirements in 3 duty points
    (without considering duty cycle / load profile)

Water pumps

Scope

- Rotodynamic water pumps for pumping clean water, including where integrated in other products.

  - Not in scope:
    - Specifically designed for water below -10 °C and above 120 °C
    - Specifically designed for fire-fighting
    - Displacement water pumps
    - Self-priming water pumps

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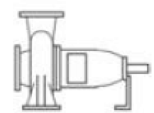
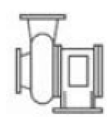
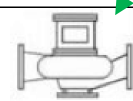
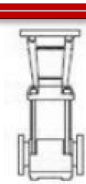
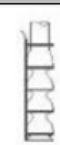
Water pumps

Scope

End suction pumps
- Design pressure < 16 bar
- 6 rpm < n_s < 80 rpm
- Rated flow > 6 m³/h
- Max shaft power 150 kW
- Max head 90m (1450 rpm)
- Max head 140m (2900 rpm)

Vertical mounted end suction

ESOB End Suction Own Bearings pump		
ESCC End Suction Close Coupled pump		
ESCCI Inline End Suction Close Coupled pump		
MS-V Vertical Multistage pump		
MSS Submersible Multistage pump		

Vertical Multistage Pumps
- Design pressure < 25 bar
- No. of stages > 1
- *Compliancy test with i=3*
- Nominal speed = 2900 rpm
- Rated flow < 100 m³/h
- Not only in-line!

Submersible Multistage Pumps
- No. of stages > 1
- *Compliancy test with i=9*
- Nominal $Ø_{out}$ = 4”
- Nominal speed = 2900 rpm
- 0°C < Operating < 90°C

Water pumps

Ecodesign requirements & dates

- From January 1st, 2013:
  - At best efficiency point have at least $(\eta_{BEP})_{min\ requ}$, when calculated with the C-value for MEI = 0.1
  - At part load point have at least $(\eta_{PL})_{min\ requ}$, when calculated with the C-value for MEI = 0.1
  - At overload point have at least $(\eta_{OL})_{min\ requ}$, when calculated with the C-value for MEI = 0.1
  - Meet various product information demands (1-15) including: Minimum efficiency index: *MEI* ≥ [*x,xx*], year of manufacture etc.
- From January 1st, 2015:
  - Same first three points as above, but with the C-value for MEI = 0.4

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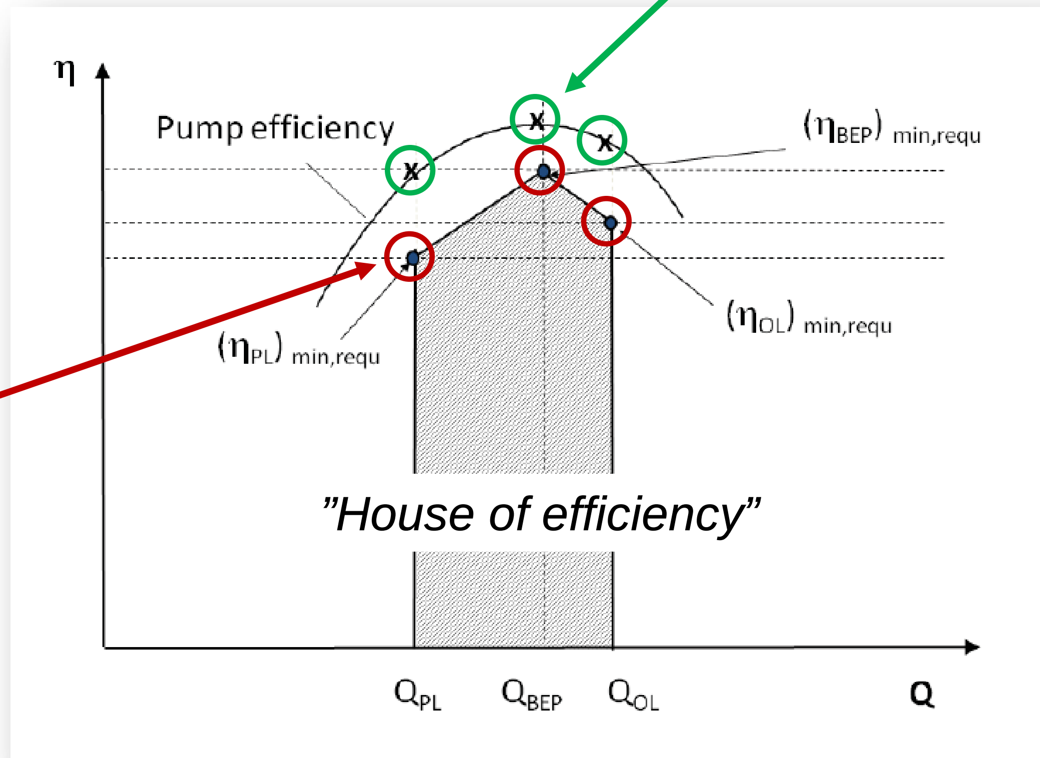
Water pumps

Test method

Test results

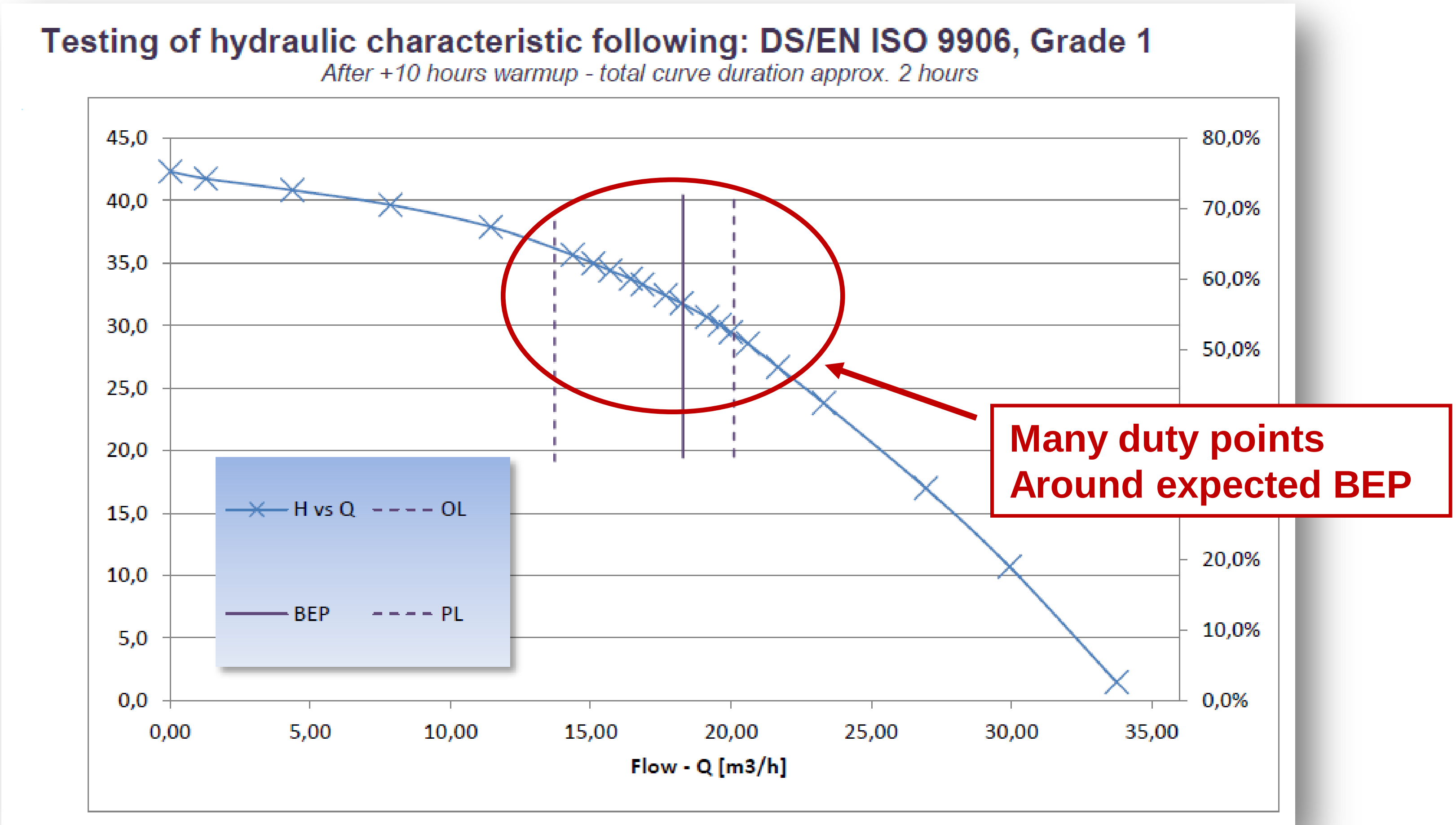
Requirements from regulation



- Test standards used:
  - ISO 9906:2012 – The "bible" of pump testing
  - prEN 16480 – Dedicated standard for ecodesign (incl. cross references etc.)

Water pumps

Test method, step 1 – Full pump curve



Water pumps

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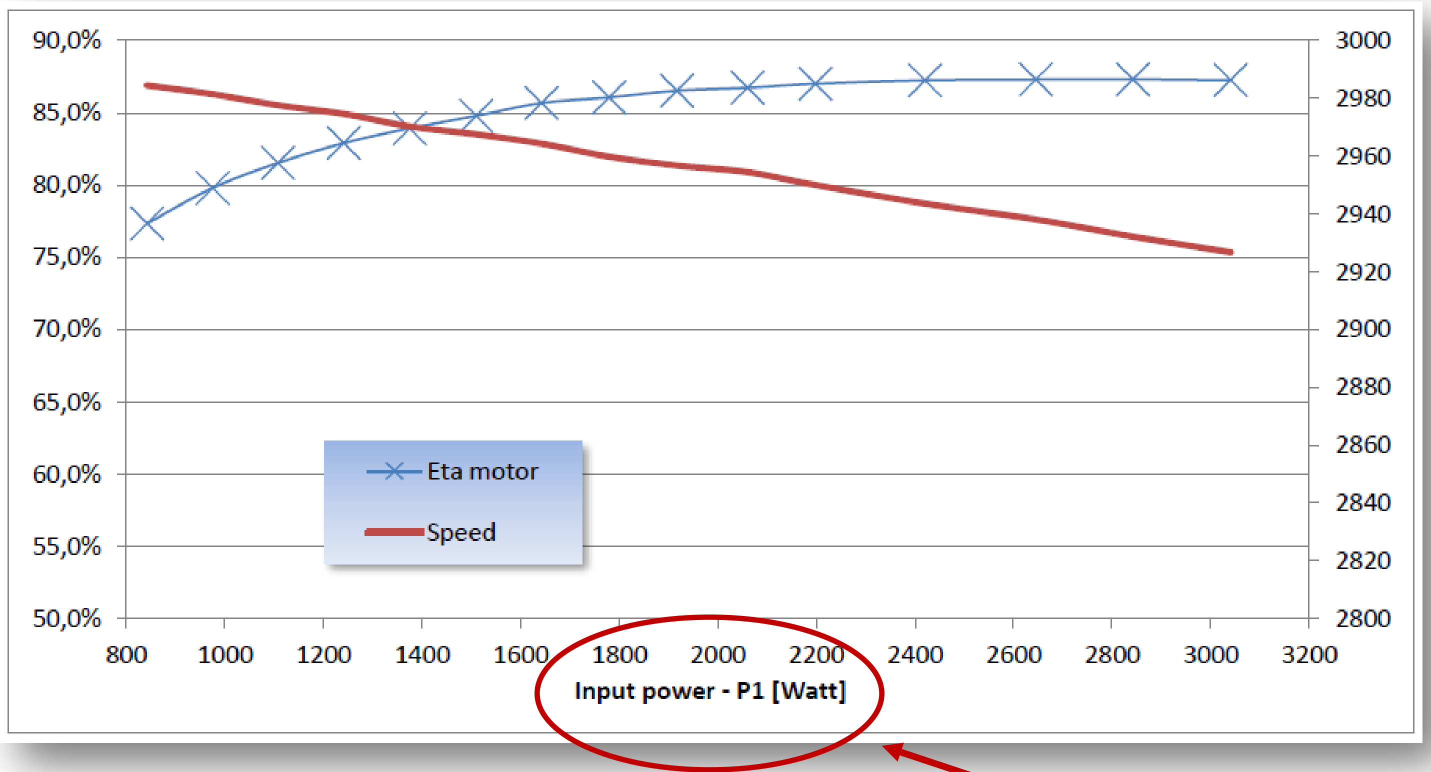
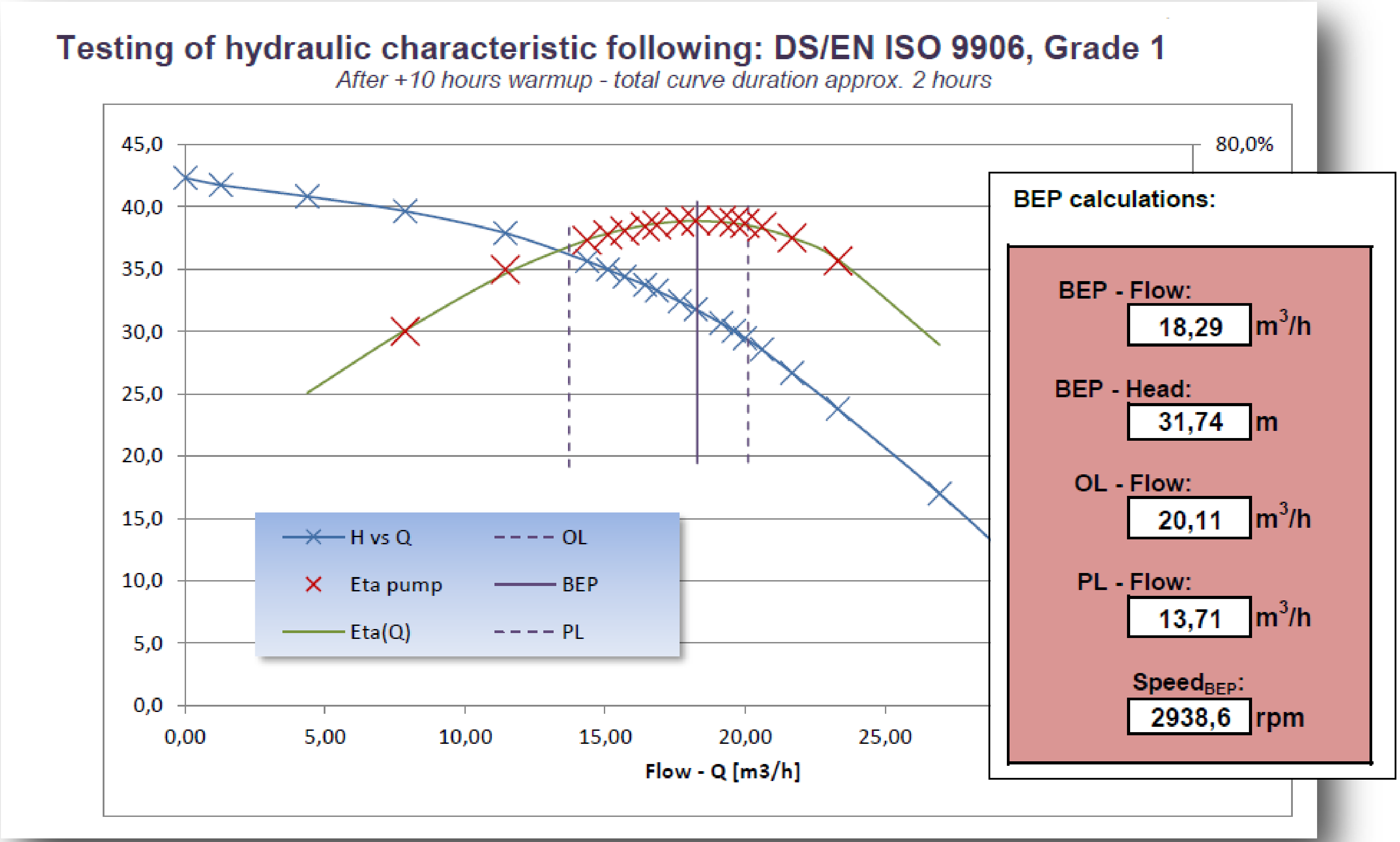
Test method, step 2 – Dismantle pump & partial motor curve



Efficiency as function of input power

Water pumps

Test method, step 3 – Hydraulic efficiency curve (motor excluded)



Water pumps

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Test method, pre-step 4 – Calculation of requirements & compliancy check

The formula for calcul

$(\eta_{BEP})_{min\ requ} = 8$

Where,

$x = \ln(n_s)$; $y = \ln$
found in Table.

$$n_s = n \cdot \frac{\sqrt{Q_{BEP}}}{(\frac{1}{i} H_{BEP})}$$

Minimum efficiency index (MEI) and its corresponding C-value depending on the pump type and speed

$C_{PumpType,rpm}$ / C-value for MEI	MEI = 0,10	MEI = 0,40
C (ESOB, 1 450)	132,58	128,07
C (ESOB, 2 900)	135,60	130,27
C (ESCC, 1 450)	132,74	128,46
C (ESCC, 2 900)	135,93	130,77
C (ESCCi, 1 450)	136,67	132,30
C (ESCCi, 2 900)	139,45	133,69
C (MS-V, 2 900)	138,19	133,95
C (MSS, 2 900)	134,31	128,79

The requirements for part load (PL) and over load (OL) conditions are s[...]ose for 100 % flow (η_{BEP}).

$$(\eta_{PL})_{min,\ requ} = 0{,}947 \cdot (\eta_{BEP})_{min,\ requ}$$

$$(\eta_{OL})_{min,\ requ} = 0{,}985 \cdot (\eta_{BEP})_{min,\ requ}$$

New requirement is 4.24 % point higher

Water pumps

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Values derived from measurements:

Q_{BEP}: 18,29 m^3/h

Q_{OL}:

$$n_s = n \cdot \frac{\sqrt{Q_{BEP}}}{(\frac{1}{i} H_{BEP})^{\frac{3}{4}}} \quad [\min^{-1}]$$

$(\eta_{BEP})_{\text{min requ}} = 88{,}59\ x + 13{,}46\ y - 11{,}48\ x^2 - 0{,}85\ y^2 - 0{,}38\ x\ y - C_{\text{Pump Type,rpm}}$

Where,

$x = \ln(n_s)$; $y = \ln(Q)$ and ln = natural logarithm and Q = flow in [m^3/h]; n_s = specific speed in [$\min^{-1}$]; C = value found in Table.

Requirements:

$(\eta_{BEP})_{\text{min req}}$ =	59,8
$(\eta_{PL})_{\text{min req}} = 0{,}947 \cdot (\eta_{BEP})_{\text{min req}}$ =	56,7
$(\eta_{OL})_{\text{min req}} = 0{,}985 \cdot (\eta_{BEP})_{\text{min req}}$ =	58,9

Results:

$(\eta_{BEP})_{\text{meas.}}$ =	69,1 ±0,85	Passed
$(\eta_{PL})_{\text{meas.}}$ =	65,6 ±0,93	Passed
$(\eta_{OL})_{\text{meas.}}$ =	68,5 ±0,81	Passed

Summarized result of pump tested in compliance to ECO-Design regulation 547/2012: **Passed**

ssed

ssed

ssed

Minimu

$C_{\text{PumpType,rpm}}$

C (ESCCi, 2 900)	139,45	133,69
C (MS-V, 2 900)	138,19	133,95
C (MSS, 2 900)	134,31	128,79

The requirements for part load (PL) and over load (OL) conditions are set at slightly lower values than those for 100 % flow (η_{BEP}).

$(\eta_{PL})_{\text{min, requ}} = 0{,}947 \cdot (\eta_{BEP})_{\text{min, requ}}$

$(\eta_{OL})_{\text{min, requ}} = 0{,}985 \cdot (\eta_{BEP})_{\text{min, requ}}$

Summarized result of pump tested in compliance to ECO-Design regulation 547/2012: Passed

ilac-MRA DANAK TEST Reg. nr. 300

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Circulators

Introduction

- Ecodesign regulation on circulators was first decided and published in the Official Journal of the European Union in the summer of 2009 (No.: 641/2009)
  - Based on European preparatory study Lot 11, finished February 2008
- First tier came into force on January 1st, 2013, The second: August 1st, 2015
- Estimated annual energy savings of 23 TWh by 2020
  (Compared to no measures)
- This is a regulation focusing on the extended product *(motor, control, pump, duty points)*
  - Weighted power consumption in 4 duty points
    (Taking duty cycle / load profile into account)
- The regulation was amended in the summer of 2012 due to “Loop hole” problems! (EU regulation no.: 622/2012)

Circulators

Scope

- Glandless standalone circulators and glandless circulators integrated in products.
  - Rated hydraulic power between 1 W and 2.500 W
  - Not in scope:
    - Drinking water circulators (except for product information)
    - Identical replacement circulators in products
      - Placed before August 1st, 2015
      - Until January 1st, 2020

Circulators

Ecodesign requirements & dates

- From January 1st, 2013:
  - Glandless standalone circulators, with the exception of those specifically designed for primary circuits of thermal solar systems and of heat pumps, shall have an energy efficiency index (EEI) of not more than 0.27
  - Meet various product information demands including:
    Energy Efficiency Index: EEI ≤ 0.[xx], Benchmark most efficient etc.
- From August 1st, 2015:
  - Glandless standalone circulators and glandless circulators integrated in products shall have an energy efficiency index (EEI) of not more than 0.23
  - Also integrated circulators shall meet various product information demands including: *Energy Efficiency Index: EEI ≤ 0.[xx]*

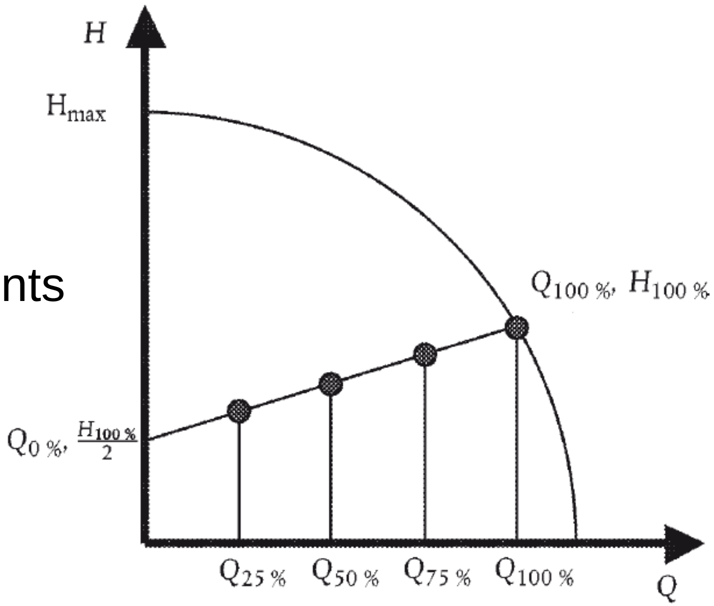
Circulators

Test method

Weighted power consumption in 4 duty points compared to a reference power P_{ref}

$$EEI = \frac{P_{L,avg}}{P_{ref}} \cdot C_{20\,\%},\ \text{where}\ C_{20\,\%} = 0{,}49$$

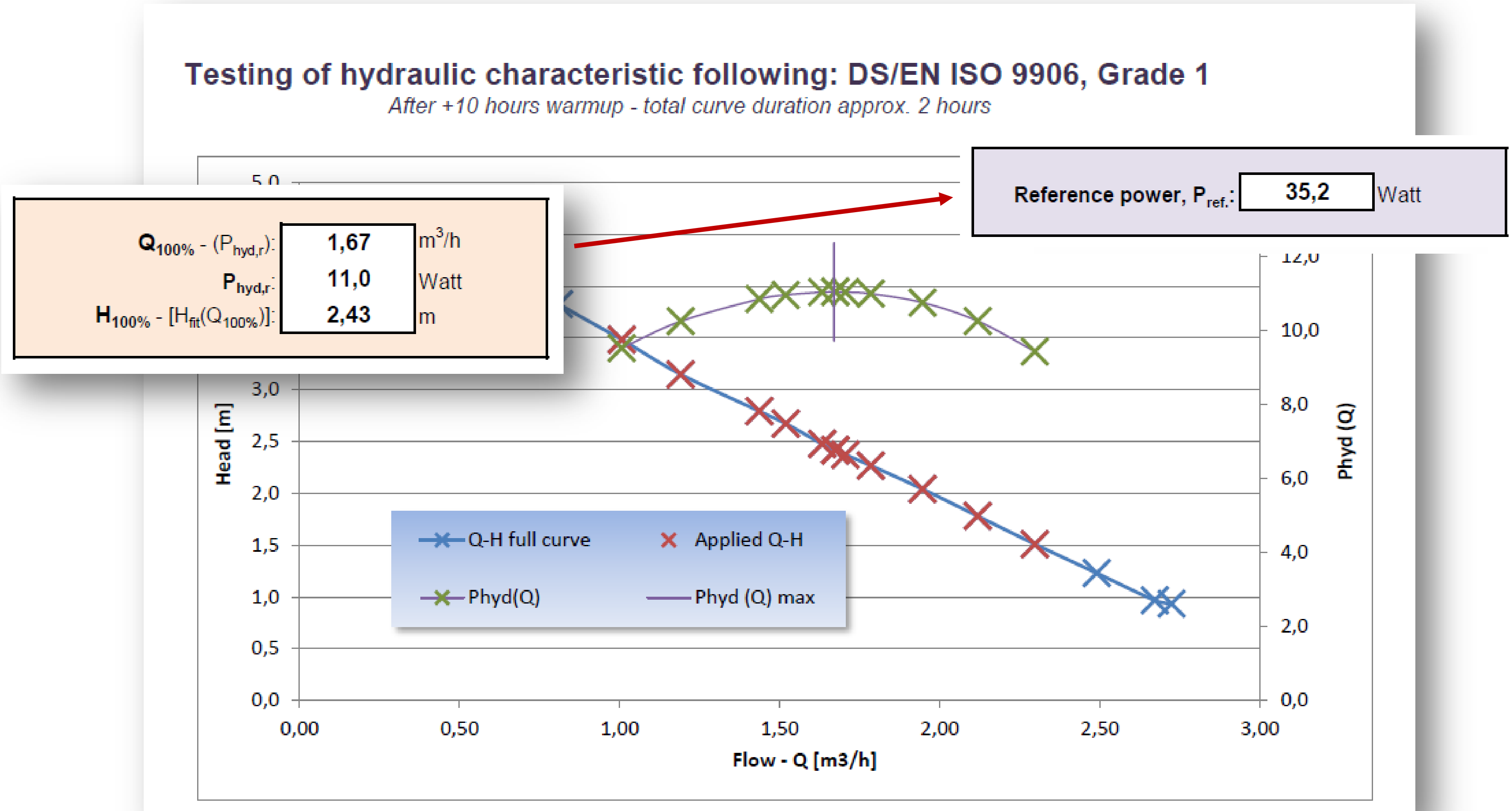
$$P_{ref} = 1{,}7 \cdot P_{hyd} + 17 \cdot (1 - e^{-0{,}3 \cdot P_{hyd}}),\ 1\ \text{W} \leq P_{hyd} \leq 2\ 500\ \text{W}$$



- Test standards used:
  - ISO 9906:2012 – The “bible” of pump testing
  - DS/EN 16297 series – Dedicated standards for ecodesign *(incl. cross references etc.)*

Circulators

Test method, step 1 – Full pump curve on max speed



Circulators

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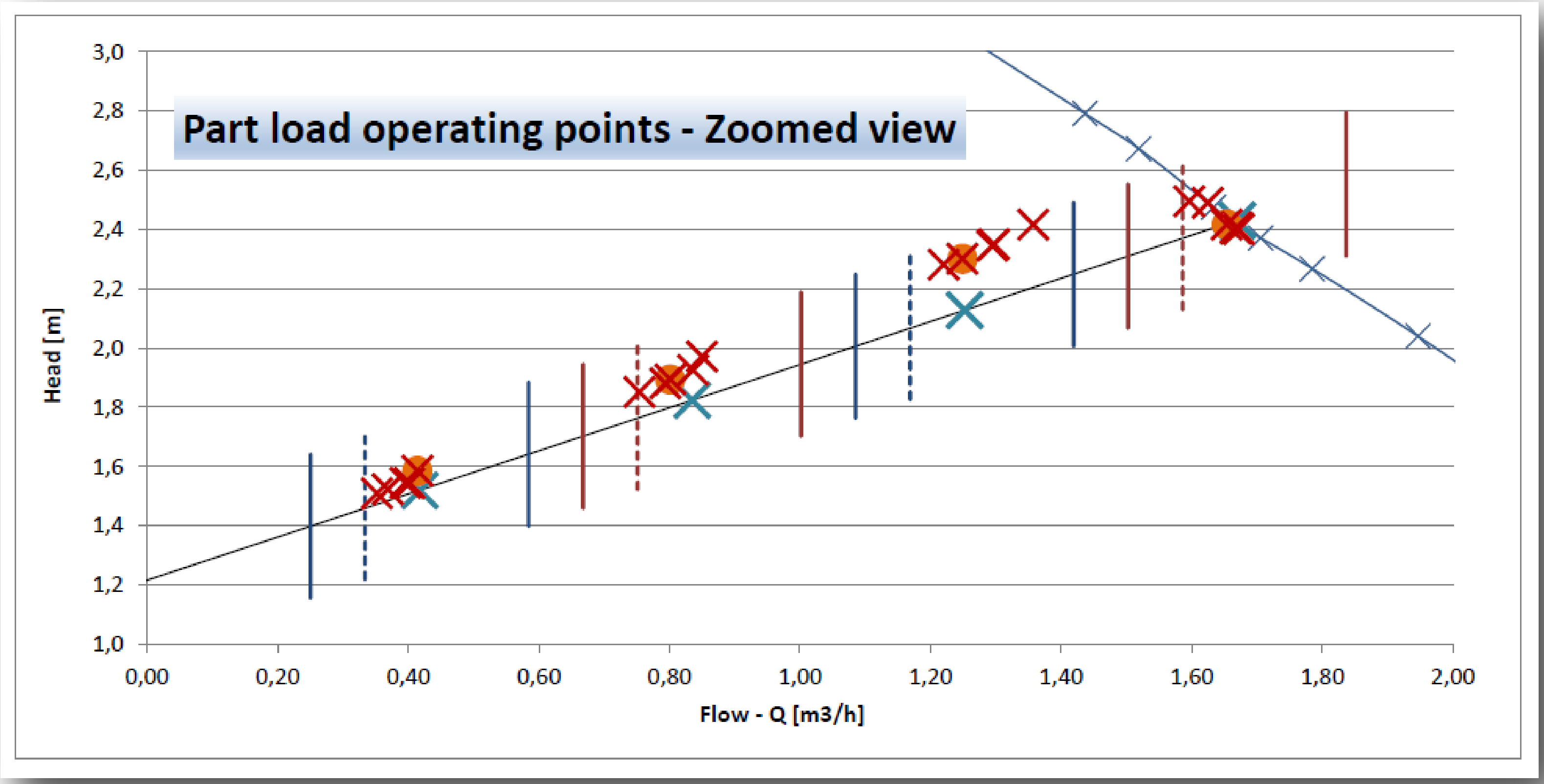
Test method, step 2 – 4 part load duty points



$Q_{100\%}$:	1,67	m³/h
$H_{100\%}$:	2,43	m

$Q_{75\%}$:	1,25	m³/h	$H_{75\%}$:	2,13	m
$Q_{50\%}$:	0,83	m³/h	$H_{50\%}$:	1,82	m
$Q_{25\%}$:	0,42	m³/h	$H_{25\%}$:	1,52	m

Circulators

Test method, step 3 – 4 part load duty points

4 x measured power

Measured / Selected values:

$Q_{100\%}$:	1,65	m^3/h	$H_{100\%}$:	2,42	m	---	$P_{1,\,100\%,\,meas}$:	31,2	Watt
$Q_{75\%}$:	1,25	m^3/h	$H_{75\%}$:	2,30	m	---	$P_{1,\,75\%,\,meas}$:	23,5	Watt
$Q_{50\%}$:	0,80	m^3/h	$H_{50\%}$:	1,89	m	---	$P_{1,\,50\%,\,meas}$:	14,5	Watt
$Q_{25\%}$:	0,41	m^3/h	$H_{25\%}$:	1,59	m	---	$P_{1,\,25\%,\,meas}$:	9,2	Watt

Load profile, average compensated power, DS/EN 16297 part 2

$Q_{100\%}$:	L1 = 6%	$P_{100\%}$:	1,88	1,01	Compensated	$P_{L,\,wieghted}$:	14,5	Watt
$Q_{75\%}$:	L2 = 15%	$P_{75\%}$:	3,52	1,00	Compensated	$P_{ref.}$:	35,2	Watt
$Q_{50\%}$:	L3 = 35%	$P_{50\%}$:	5,07	1,00	Compensated			
$Q_{25\%}$:	L4 = 44%	$P_{25\%}$:	4,05	1,00	Compensated	$EEI_{C20\% = 0,49}$:	0,2023	

"Blaue Ängel weighting"

Final EEI = 0.20; Passed

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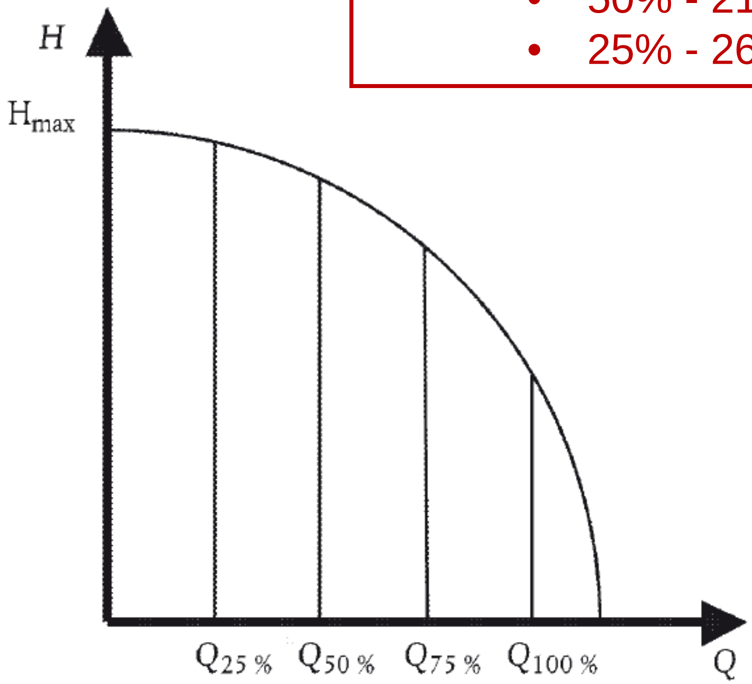
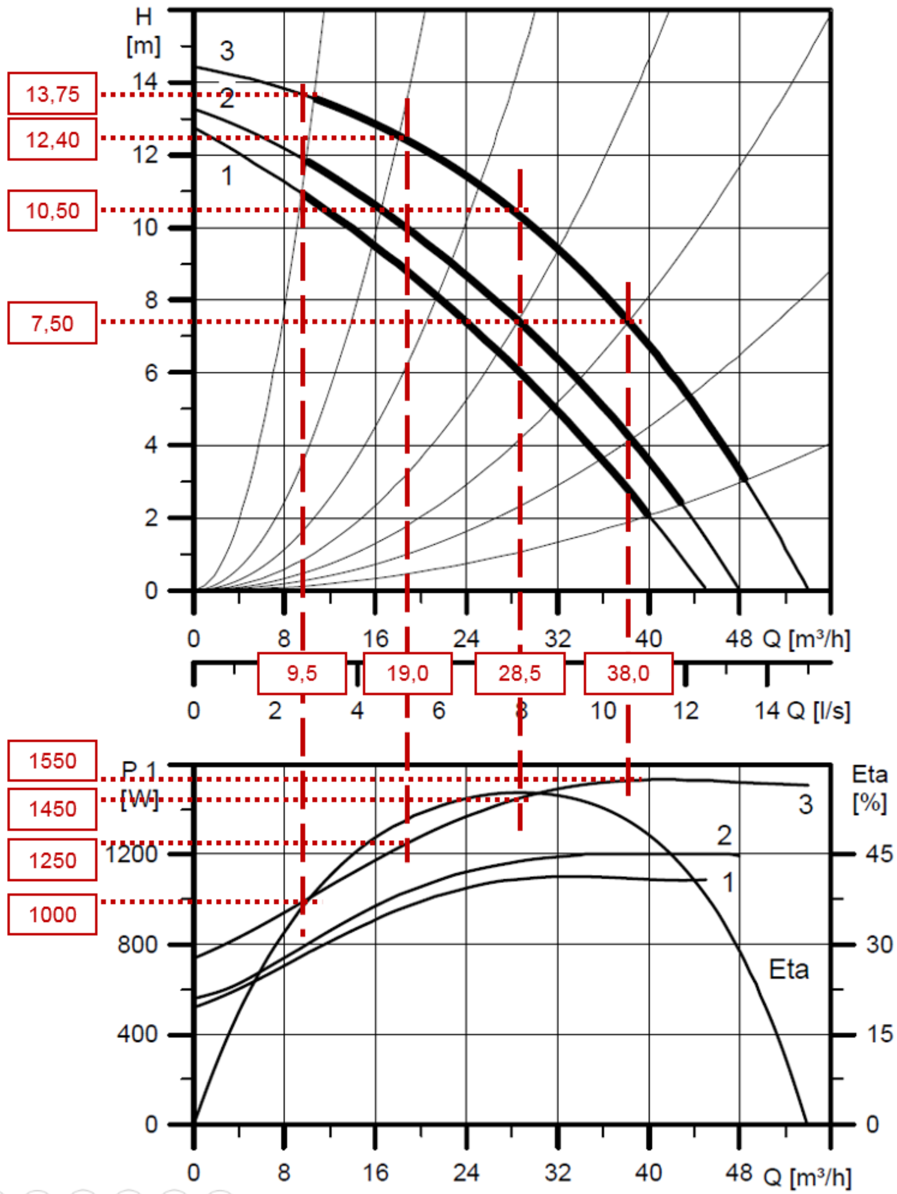
- Time for live calculation…
  - But first a short intro

"Blaue Ängel weighting" 6000 h/y:

- 100% - 360h
- 75% - 900h
- 50% - 2100h
- 25% - 2640h

Flow [%]	Time [%]
100	6
75	15
50	35
25	44





H [m]
Q [m³/h]
Q [l/s]
P 1 [W]
Eta [%]
Eta
1
2
3
13,75
12,40
10,50
7,50
9,5
19,0
28,5
38,0
1550
1450
1250
1000

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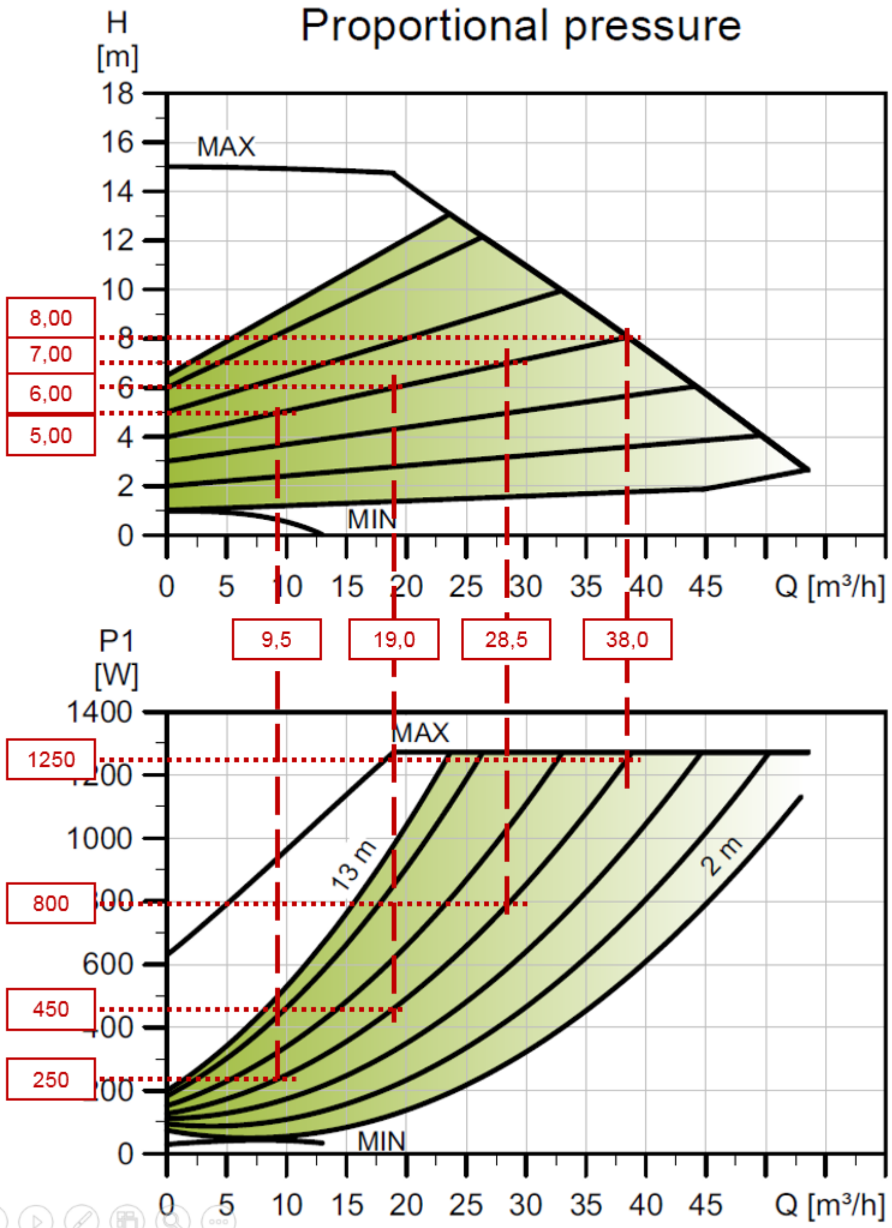
Proportional pressure



Webinar on Pumps & Circulators

Thank you for listening

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4E EMSA – Electrical Motor Systems Annex, http://motorsystems.org