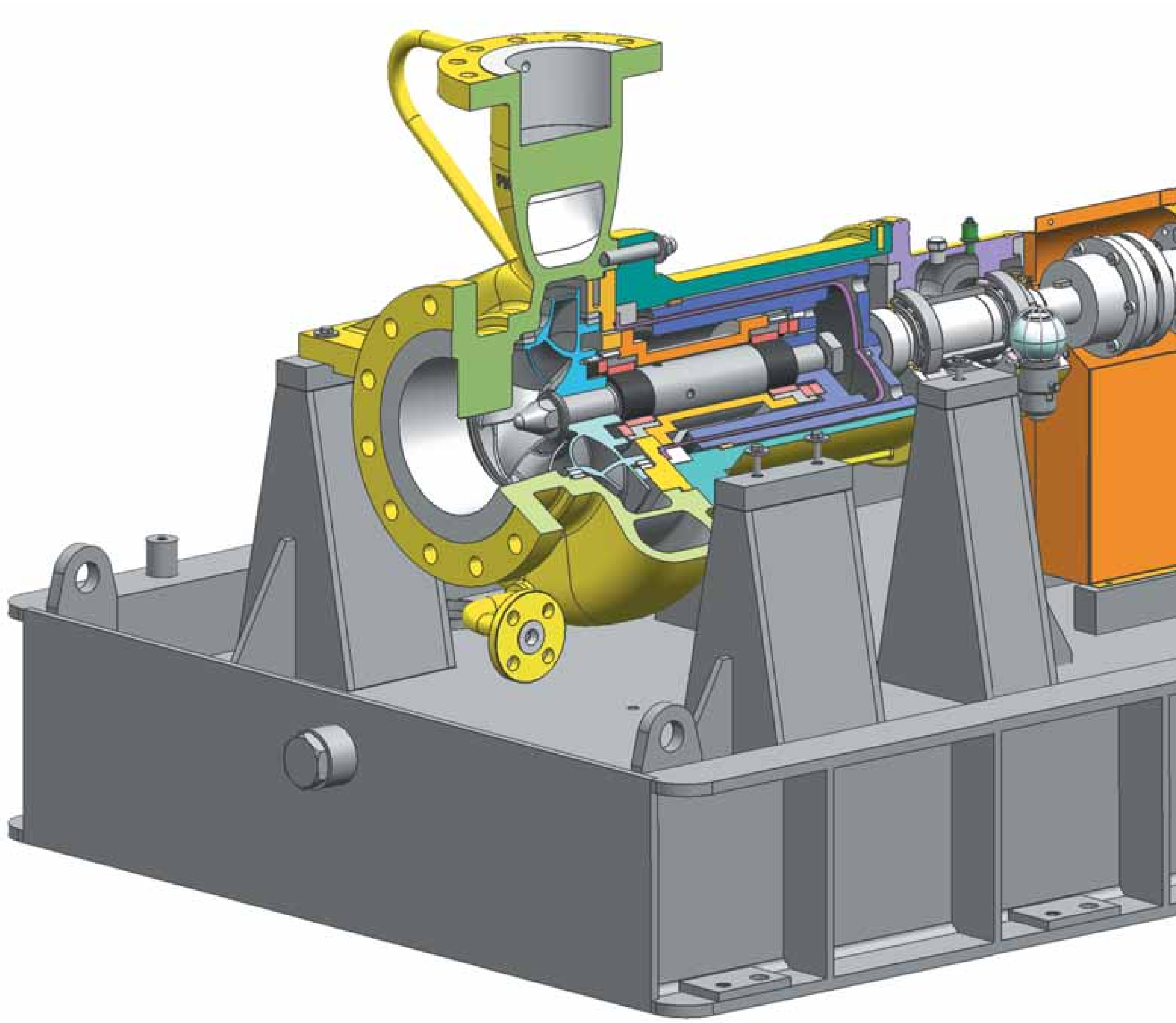
Technical Paper

ZeroLoss™ Containment Shells for Magnetic Drive Sealless Pumps



Since the introduction of the API 685 standard, Sundyne has developed and extended its range of magnetic drive technology, centrifugal pumps.

The primary driver for the development of magnetic drive pumps was and continues to be safety plus now the significant environmental benefits. This necessitates the need for complete containment of hazardous process liquids within a hermetically sealed shell.

The containment shell for magnetic drive pumps has to date been of a metallic construction in order to achieve the required strength whilst maintaining a relatively thin shell wall thickness.

An unfortunate consequence of the use of metallic containment shells is that the rotating magnetic couplings induce eddy currents in the stationary metallic shell resulting in a reduction in efficiency of such a system. This manifests itself as heat in the metallic containment shell.

For many years, material developments have been monitored by engineers at Sundyne, who have been looking for a non-conductive material of high strength to produce a ZeroLoss™ shell.

Metallic Shell Performance

The amount of energy lost in a magnetic coupling is dependent on:

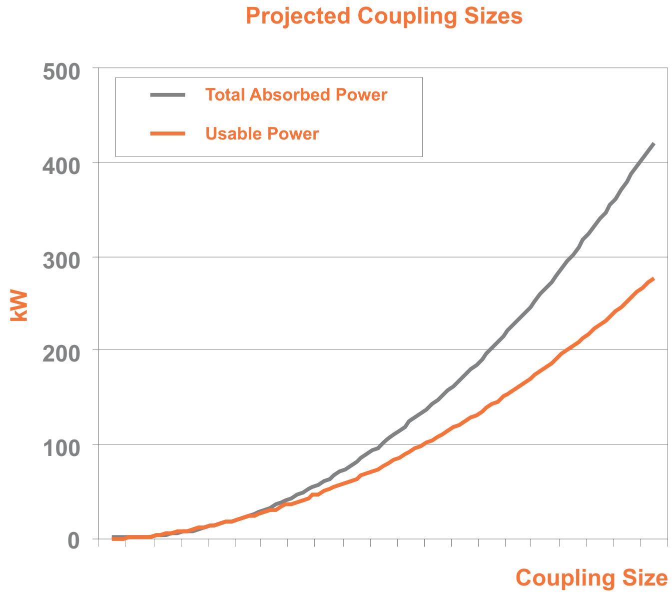
- The electrical resistivity of the shell material.
- The thickness of the shell material.
- The strength of the magnets.
- The linear velocity of the coupling.

For a magnetic coupling arrangement, with a containment shell, the 'electrical resistivity' is a fixed material property and the 'magnetic strength' is fixed for the type and size of magnets used in different magnetic couplings.

The losses change with the square of the change in rotational speed. For example, if a pump is rotating initially at 1750 rpm with a known energy loss, if the rotational speed of the pump is doubled to 3500 rpm the energy loss would increase by a factor of 4.

The influence of the linear coupling velocity means that larger diameter couplings will have higher losses due to increased linear velocities.

This influence is illustrated graphically for a typical range of HMD Kontro magnetic couplings and then extrapolated for hypothetical larger coupling sizes:



The power loss is the difference between the 'total absorbed' and 'usable' power curves. With the largest couplings that HMD Kontro supply, the losses are significant with a metallic containment shell.

It can be seen that whilst metallic containment shells are used, there is a limit to the economic viability of increasing coupling size (with the cost of increased material sizes, larger number of magnets, etc) with the growth of the associated power loss and also dissipating the energy lost by the coupling into the shell. This may become an insurmountable problem for certain applications.

ZeroLoss™ Shell Material Properties

The ZeroLoss containment shell was created by HMD Kontro -- A Sundyne brand. The containment shell is an engineered composite material combining poly-ether-ether-ketone (PEEK) and carbonfibres. The ZeroLoss shell is a quasi-isotropic, multi-ais construction which means that the material strength is close to being equal in all directions.

The listed properties of the ZeroLoss Containment Shell material are:

- High tensile strength
- High electrical resistivity (> 1.56 E-04 Ω.m)
- Temperature range: – 40° C to +120° C / -40° F to +250° F
- Resistant to a wide range of chemicals
- Fatigue properties better than metal
- Fire resistant
- Does not suffer from brittleness at sub-zero temperatures
- Resistant to thermal shock
- Impact resistant
- Tough and ductile
- Excellent post-moulding machinability
- Recyclable (environmentally friendly)
- Approximately 20% weight of comparable grade of steel
- Approximately 50% the coefficient of expansion of comparable grade of steel

Tensile Strength

The determination of the strength of the composite material at a given feature of the containment shell is governed by theories of material failure, which rely upon 'classical laminate theory' to provide data. This is entered into a 'quadratic failure criteria' calculation. As a consequence the tensile strength will vary slightly which is why a value is not included in the table.

Electrical Resistivity

The claim to be a ZeroLoss containment shell is associated with the electrical resistivity of the material of construction. The measured electrical resistivity of the engineered composite material is 1.56 E-04 Ω.m.

This electrical resistivity is 212 times higher than the resistivity of a stainless steel that might be used in the construction of a containment shell. However the measurement of the electrical resistivity of the composite material is made with the carbon fibres aligned along the direction of resistance measurement.

The magnetic flux of the pump coupling will produce eddy currents that traverse through the section of the aligned carbon fibres, as opposed to running in the same direction as the direction of fibre alignment. As a consequence the electrical resistivity of the engineered composite material – as used in the ZeroLoss shell –will be much greater than 1.56 E-04 Ω.m and power losses (due to eddy currents) tend towards zero when determining losses in testing.

The ZeroLoss GSP Frame 3 Containment Shell

Pump cartridge with
ZeroLoss™ containment shell

ZeroLoss™ Shell Benefits

The benefits provided by the HMD Kontro ZeroLoss™ containment shell are:

- **Lower operational or running costs.**
  The operational costs of the HMD Kontro API 685 pump incorporating the ZeroLoss™ shell are significantly reduced, because the elimination of containment shell eddy current losses results in reduced energy consumption.

- **Lower capital costs.**
  There is an opportunity with equipment incorporating the ZeroLoss™ shell to reduce motor size and pump-set envelope. As a consequence the capital cost of the equipment would reduce commensurate with the specification of the equipment required.

- **Improved handling of liquefied gases.**
  Where a process liquid is pumped at a pressure and temperature close to the point at which it will vapourise, the elimination of the eddy current heating effect – through the use of the ZeroLoss shell - will avoid the possibility of a phase change from liquid to gas and the potential for damage to bearings through dry running and other consequences.

- **Improved handling of heat sensitive liquids.**
  In a similar way, the ZeroLoss shell will prevent deterioration of heat sensitive liquids, because the eddy current heating effect is eliminated.

- **More robust and greater tolerance of closed discharge conditions or partial dry run conditions.**
  A metallic shell relies upon the liquid pumped to conduct away the heat generated by eddy currents. With an absence of liquid, a metallic containment shell will very quickly heat to temperature levels that will cause damage to parts of the pump. With the ZeroLoss shell, there is no eddy current heating and so the composite containment shell is more robust to dry run or partial dry run conditions, because it is not being heated and is not therefore dependant on liquid contact to conduct this heat away.

- **Allows the development of larger magnet drive pumps.**
  With the ZeroLoss shell the losses, the difference between the total absorbed and usable power curves, becomes zero. The limitation that exists for metallic coupling arrangements, where it becomes economically unviable to make larger sizes, 'moves much further to the right' for the ZeroLoss shell. Obviously for larger sized ZeroLoss shell, couplings; high material costs for larger sized parts and greater numbers of magnets still apply, but the economics of a greatly increased eddy current loss are absent because of the ZeroLoss shell.

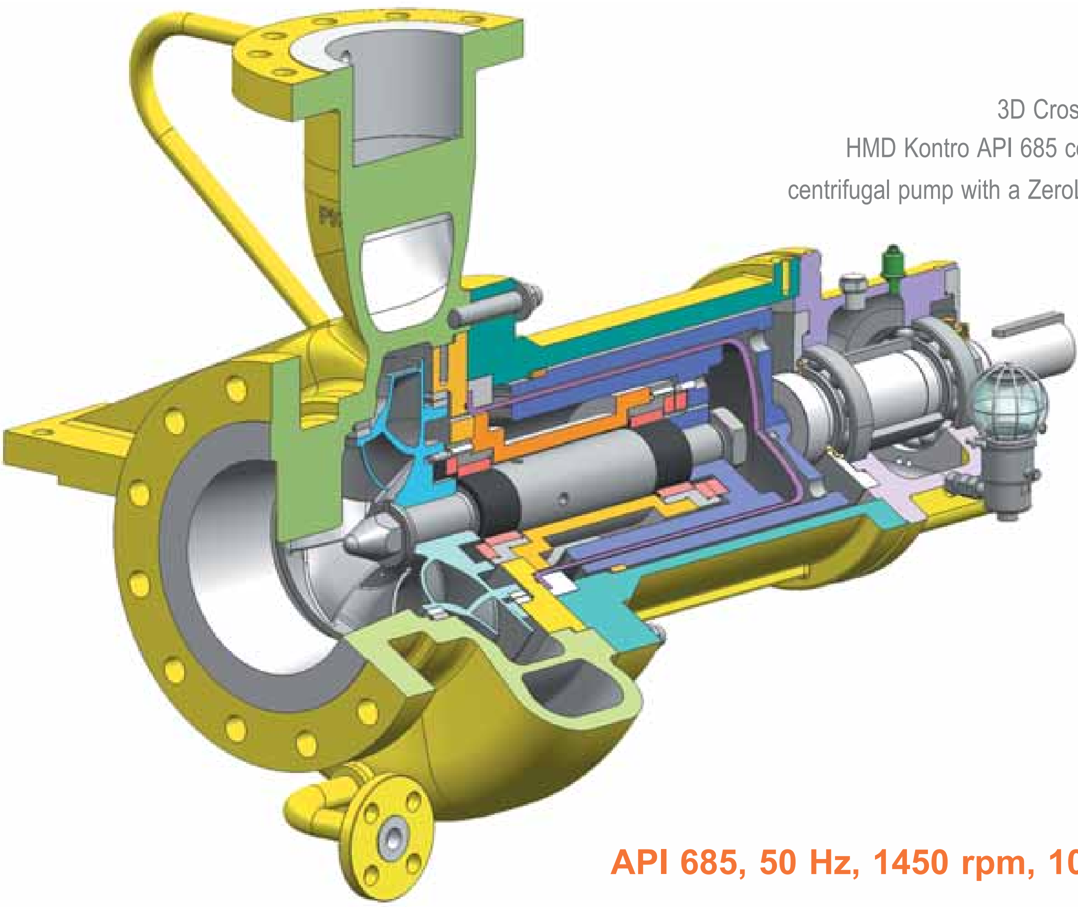
- **Allows development of higher speed pumps.**
  Eddy current losses increase with the square of rotational speed. However if the eddy current loss is zero, as achieved with the ZeroLoss containment shell, then the rotational speed can be increased in the knowledge that no increase in eddy current losses will result.

Case Study Calculations

The following case studies are used to illustrate the potential benefit of the ZeroLoss™ shell by showing the pump configuration and operational costs for a metallic and a ZeroLoss™ containment shells.

For each case study, both the metallic containment shell and the ZeroLoss™ containment shell configurations are assumed to operate 24 hours a day, for 256 days (70%) of a year, with a motor efficiency of 92% and an electrical energy cost of £0.075/kW.hr.

In all cases the magnetic coupling and containment shell have been selected in accordance to the requirements of API 685.



3D Cross-section drawing of an HMD Kontro API 685 compliant magnetic drive, centrifugal pump with a ZeroLoss™ containment shell

API 685, 50 Hz, 1450 rpm, 10x8x13" Pump

An API 685 pump is required to pump a liquid with density of 1.0 to achieve a specified flow rate and head. The pump is to operate off a 50 Hz power supply and a 10x8x13" size is selected running off a 55 kW motor, at a rotational speed of 1450 rpm.

The magnetic coupling selected – with a metallic containment shell – would cost £22,163/year to operate.

The same magnetic coupling, with a ZeroLoss containment shell would cost £20,035/year to operate.

This gives a headline saving of 10% on annual operating costs, by using a ZeroLoss™ containment shell.

API 685, 60 Hz, 1750 rpm, 8x6x15" Pump

An API 685 pump is required to pump a liquid to achieve a specified flow rate and head. The pump is to operate off a 60 Hz power supply and an 8x6x15" size is selected running off a 132 kW motor, at a rotational speed of 1750 rpm.

The magnetic coupling selected – with a metallic containment shell – would cost £53,293/year to operate.

The same magnetic coupling, with a ZeroLoss™ containment shell would cost £48,083/year to operate, but would also enable the motor size to be reduced from 132 kW to 110 kW.

This gives a headline saving of 10% on annual operating costs and a capital cost reduction through using a 110 kW motor instead of 132 kW motor, by using a ZeroLoss™ containment shell.

API 685, 50 Hz, 2900 rpm, 4x3x15" Pump

An API 685 pump is required to pump a liquid to achieve a specified flow rate and head. The pump is to operate off a 50 Hz power supply and a 4x3x15" size is selected running off a 185 kW motor, at a rotational speed of 2900 rpm.

The magnetic coupling selected – with a metallic containment shell – would cost £74,029/year to operate.

The same magnetic coupling, with a ZeroLoss™ containment shell would cost £62,108/year to operate, but would also enable the motor size to be reduced from 185 kW to 150 kW.

This gives a headline saving of 16% on annual operating costs and a capital cost reduction through using a 150 kW motor instead of 185 kW motor, by using a ZeroLoss™ containment shell.

API 685, 60 Hz, 3500 rpm, 6x4x13" Pump

An API 685 pump is required to pump a liquid to achieve a specified flow rate and head. The pump is to operate off a 60 Hz power supply and a 6x4x13" size is selected running off a 250 kW motor, at a rotational speed of 3500 rpm.

The magnetic coupling selected – with a metallic containment shell – would cost £11,0993/year to operate.

The same magnetic coupling, with a ZeroLoss™ containment shell would cost £90,157/year to operate, but would also enable the motor size to be reduced from 250 kW to 200 kW.

This gives a headline saving of 19% on annual operating costs and a capital cost reduction through using a 200 kW motor instead of 250 kW motor, by using a ZeroLoss™ containment shell.

Sundyne Sealless

ZeroLoss™ Sealless Pumps

Pump Parameters

- Temperature: -40° C to +120° C (-40° to +250° F)
- Flow Rates: Up to 2000m^3/hour / 8800 USGPM
- Heads: Up to 350m / 1140' differential
- Viscosity: Maximum 200cP
- Pressure: Up to 40 bar / 580 PSI
- Solids: Up to 5%, with a particle size of 150 microns
- Solids: Up to 8% and 250 microns with filtration
- Power: 365kW 50Hz / 400kW 60Hz
- Standards: API685 (API610) / ANSI B73.1M

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