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# C O N T E N T S

## **IFOREWORD**

As tools like big data, artificial intelligence (AI) and edge computing rapidly become a part of day-to-day business operations, the demand for computing power seems to be on a limitless upward trajectory. As a result, data centre managers are expected to increase physical and virtual capacity while also balancing efficiency, running costs and resource consumption.

As capacity requirements increase, cooling data centres is becoming more critical. However, we are fast approaching the limit of our current air cooling infrastructure. Air cooling is the default technology today, but it may not stay competitive for long due to its bulky infrastructure, high running costs, noise levels, and energy and water consumption. It is also less effective when it comes to cooling densely stored hardware.

Servers, data and businesses are at risk. Rapid or sustained overheating may cause servers and hardware to malfunction or break, resulting in data loss, downtime and disruption to critical dependent services – not to mention the cost of replacement and the risk of fines if SLAs are not met. Put simply, when a cooling system fails, a data centre fails.

At Castrol, we believe the future is liquid cooling. It promises to enhance data centre performance and future-proof facilities' ability to keep pace with our intensifying appetite for data processing. Immersion cooling can significantly reduce the energy it takes to maintain ideal data centre temperatures. Our research among data centre experts reveals that those who have already adopted immersion cooling to some extent save, on average, 15,000 MWh of energy every year compared to those who do not currently use this technology.

Despite the initial acquisition or upgrade costs involved, immersion cooling can bring down the lifetime cost of today's data centres. Data centre experts in our survey predict owners will see monetary returns on their investment in immersion cooling in three years or less.

Organisations have so far been hesitant to take the plunge. However, as the industry acknowledges the need for more efficient and less resource-intensive cooling solutions, we're preparing for immersion cooling to redefine the operational dynamics of data centres worldwide.

By using external industry expert opinions to quantify the impact immersion cooling could have on the data centre industry, this report aims to demonstrate the importance of switching to immersion cooling and showcase the benefits that it can bring.

Peter Huang, Global Vice President - Data Centre, Thermal Management, Castrol



### A hesitation to switch

### The cost of computing



The data centre experts in our research are unanimous in their belief that immersion cooling will become the dominant technology for data centres at some point in the future, with 90% considering switching their primary cooling system to immersion cooling between now and 2030.

The research respondents selected fear of leakages, a time-consuming implementation process and ongoing maintenance challenges as barriers to immersion cooling adoption.

The respondents ranked power efficiency, cooling effectiveness and cost-effectiveness as the most important attributes of data centres.

According to our research, immersion cooling can help in all three areas; saving data centres at least 15,000 MWh and 3.5 million litres of water every year, compared with those that rely entirely on air cooling (for details on how these figures were calculated, please see page 22).



15000 MWh

This report is based on data collected from external respondents, who we consider to be data centre experts, not from bp or its affiliates.

### The return on immersion

74% of data centre experts who responded to our survey believe that, despite the initial investment required to transition from air cooling to immersion cooling, the data centres that do transition will have a lower total cost of ownership. The majority of respondents believe that data centre owners will see a return on their investment in immersion cooling in three years or less. And 77% believe immersion cooling will drive millions in return across the industry.

Return is fast, but demand may grow faster; 76% of data centre experts in our research believe the industry must adopt immersion cooling within the next three years to continue to see performance improvements. They expect immersion technology to become dominant in data centre cooling in 2027 – suggesting the organisations that are not on track to reach this 'Dipping Point' could fall behind competitors who may already be strategically planning downtime and investing in immersion cooling infrastructure.

(megawatt hours) and 3.5 million litres of water saved in data centres every year.



of data centre experts believe immersion cooling will drive millions in return for businesses.







# //ABOUT THE STUDY

*The Dipping Point* is based on an anonymous survey amongst 600 data centre industry leaders, consisting of 510 data centre experts across mid-market and enterprise organisations and 90 chip manufacturers. Leaders were based in seven markets: the US, China, Germany, the Nordics, the UK, Canada, and Ireland. More details are included in the methodology on page 21.

Throughout this report, mentions of "data centre experts" and "respondents" refer to the sample of 510 data centre experts. Any responses from the 90 chip manufacturers have been labelled accordingly.

This report is based on data collected from external respondents, who we consider to be data centre experts, not from bp or its affiliates.





# //A HESITATION TO SWITCH



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Cooling server components by submerging them in a thermally conducting, electrically insulating liquid might seem futuristic, but immersion cooling isn't science fiction – for many, it's a present-day reality.

The data centre experts in our research believe that, over time, immersion cooling will become the dominant technology for data centres. To accommodate the data demands of today let alone those of tomorrow – over a third (36%) of the experts considered switching their primary system to immersion cooling before 2025, and nine out of ten are thinking about switching to immersion cooling as a primary system between now and 2030.

"As data centres face mounting pressures from AI workloads, real-time analytics and sustainability mandates, immersion cooling emerges as a promising solution. Its potential to significantly reduce energy and water consumption while supporting higher compute densities positions it as a strong contender for cooling next-generation data centres. However, widespread adoption hinges on addressing the substantial infrastructure and hardware compatibility challenges that currently exist."

Poh Seng (PS) Lee, Professor of Mechanical Engineering, National University of Singapore (NUS)





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"90% data centre experts are thinking about switching to immersion cooling as a primary system between now and 2030."



# **IPRESSURE TO PERFORM**

Data centre managers are under pressure from all directions. Owners are keen to use every bit of physical, electrical and virtual capacity, and customers expect maximum bandwidth and reliability at any given moment. At the same time, there is a drive to reduce data centre water use, energy consumption, carbon emissions and heat discharge<sup>1,2,3,4</sup>.

The key is having an effective cooling technology in place; 74% of respondents believe that immersion cooling is now the only option for data centres to meet the current compute power demands. This is backed by the same number who say that air cooling systems will struggle to handle the increase in data traffic. 77% of respondents believe that immersion cooling systems effectively support current network demands, enabling data centres to handle large-scale data processing, storage and distribution.

They also see immersion cooling playing an important role in future-proofing businesses. Three-quarters of the data centre experts in our research believe the virtual capacity – computing power and speed – of data centres that use immersion cooling is fit to handle current and future software demands. A similar proportion (73%) are confident that the physical capacity servers, storage devices and network equipment – of data centres that use immersion cooling systems is fit to handle current and future hardware demands.

Importantly, immersion cooling offers data centre managers an opportunity to reduce resource use; three-quarters (76%) of data centre experts in our research believe that immersion cooling will help data centre owners significantly reduce their energy and water consumption.



### 77%

of data experts believe that immersion cooling systems effectively support current network demands.

### 76%

of data centre experts in our research believe that immersion cooling will help data centre owners significantly reduce their energy and water consumption.

### 74%

of data centre experts believe that immersion cooling is now the only option for data centres to meet the current compute power demands.

### 73%

are confident that the physical capacity (servers, storage devices and network equipment) of data centres that use immersion cooling systems is fit to handle current and future hardware demands.

The environmental cost of AI (2024) The Financial Times. Available at: https://www.ft.com/content/32<u>3299dc-d9d5-</u> 482e-9442-f4516f6753f0 (Accessed: 16 October 2024).

<sup>2</sup> Zahn, M. (2024) Data centers fuel AI and crypto but could threaten climate, experts say, ABC News. Available at: https://abcnews.go.com/Business/data-centers-fuel-ai-crypto-threaten-climate-experts/story?id=109342525 (Accessed: 16 October 2024).

<sup>3</sup> Thornhill, J. (2024) AI is a green curse as well as a blessing, The Financial Times. Available at: https://www. ft.com/content/61c05fec-0542-4dcf-979e-46b4826614d7 (Accessed: 16 October 2024).

<sup>4</sup> Bryan, K. (2024) Data centres curbed as pressure grows on electricity grids, The Financial Times. Available at: https://www.ft.com/content/53accefd-eca7-47f2-a51ec32f3ab51ad5 (Accessed: 16 October 2024).











### WHY IS THERE A HESITATION TO SWITCH

So, if the benefits of immersion cooling are clear, why is there a hesitation to switch? The data centre experts in this research select their top barriers to immersion cooling adoption as:

- 1. The potential for fluid leakages (38%)
- 2. Time-consuming [to implement] (31%)
- 3. Maintenance challenges (31%)

In an industry where uptime is critical, any risk of service interruption is a valid concern. Retrofitting an existing facility with a new cooling system will require scheduled downtime, and managers must make sure to install safety measures that prevent and minimise leaks – and train staff to test, monitor and maintain immersion cooling systems.

However, a relatively even spread of concerns from low proportions of data centre experts suggests that no single challenge is an insurmountable barrier to immersion cooling adoption.





# **THE COST OF COMPLETING**



### The cost of computing

An ideal data centre performs reliably and effectively; comfortably handling high process loads while consuming as little power and resources as possible. But this is getting harder to deliver as servers are packed more densely and become more energy-intensive to cool. Without a fundamental change in infrastructure, data centres may cost more money and resources to operate, and put data and uptime increasingly at risk. It's time for a reset.

"We have never experienced such rapid advancement in chip density. Over the past 20 years, a CPU generation typically lasted 3 – 5 years; now, we're seeing two generations per year to meet the demands of increasingly power-intensive applications. This surge brings increased heat and rack density, and while traditional air cooling systems remain effective for lower power density chips and racks, they struggle with anything over 50 KW. With future requirements approaching 1,000 KW, enhanced cooling infrastructure will be essential for data centres to keep pace."

Peter Huang, Global Vice President - Data Centre, Thermal Management, Castrol





**Power efficiency** 

# 26%

**Cooling effectiveness** 

### 70.11

# 25%

20.5

**Cost effectiveness** 

### The value of operational consistency

The data centre experts in this research select their most important data centre attributes as being:

- Power efficiency (26%)
- Cooling effectiveness (26%)
- 3. Cost effectiveness (25%)

There is no single attribute that defines a 'good' data centre. As aspects such as power, cost and cooling efficiencies are all equally important, it's therefore crucial for owners, managers and IT technicians to develop a holistic approach when setting up and managing their data centres.

"Although immersion cooling requires a larger upfront investment, the long-term savings in energy, water, and maintenance costs make it a cost-effective option over the lifespan. By eliminating the need for air circulation and temperature management systems, immersion cooling reduces the energy required to cool servers. Additionally, these systems can prolong hardware lifecycles by preventing thermal strain, reducing the need for frequent replacements and ensuring higher performance under heavy workloads. These factors are becoming more important as data centres strive to optimise both their environmental impact and their bottom line, particularly in high-performance computing environments."

PS Lee, Professor of Mechanical Engineering, NUS

The definition of data centre performance is complicated further by differing priorities between stakeholders. For example, data centre owners are particularly likely to be thinking about the lifespan of their facilities, with "future-proofing" emerging as one of their top priorities – but this was not a top consideration for senior IT technicians in our research.











### **Edge computing**

As traditional computing architecture begins to crumble under the volume and speed of today's digital demands, data-intensive businesses are increasingly adopting edge-computing. Instead of relying on a single, centralised data centre, this emerging infrastructure model uses many smaller data centres to bring networks and data storage closer to end users.

Immersion cooling is the optimum choice for edge computing. As local data hubs grow and flex with demand, immersion cooling can comfortably scale up with them. Air cooling is restrictive; the space it needs limits the locations in which local data centres can be built, making it an inefficient choice for both larger and smaller facilities.

The data centre experts in our research also believe that immersion cooling can improve several important features for edge computing, including efficiency (43%), network/software capacity (42%) and the reliability of infrastructure (39%). Perhaps because of this, seven out of ten believe that immersion cooling will be critical to the success of edge computing.



Network/software capacity

Reliability of infrastructure

Maintenance of edge computing systems Space utilisation/ physical capacity Scalability of infrastructure in line with increased internet traffic



### The resources in numbers

The data centre experts in our research recognise that all of these factors efficiency, future-proofing and reduced resource consumption - can be addressed through immersion cooling. But do they know to what extent?

Based on figures reported by data centres that currently use a combination of cooling technologies – not necessarily immersion cooling exclusively – these savings are conservative estimates.

These figures give a clear indication of how immersion cooling can help data centres meet the various needs of managers and owners, enabling them to run much more efficiently, reduce resource consumption and lower cooling-associated costs.

This report is based on data collected from external respondents, who we consider to be data centre experts, not from bp or its affiliates.





### Industry impact: Energy

Based on the data centres represented in this study, those that do not currently use immersion cooling consume, on average, almost 50,000 MWh of energy annually.

For those in the research sample that have already adopted immersion cooling to some extent, this figure drops to an average of 35,000 MWh annually – a reduction of 15,000 MWh, or 30%, which equates to approximately 75,000 MWh over five years.

After transition



This research finds the average data centre that doesn't currently use immersion cooling consumes almost 4 million litres of water annually.

Of the data centres in this research that have adopted immersion cooling as a primary system (although not necessarily the only system), 53% already report an overall decrease in water usage. Among these facilities, data centre experts declare an average water use reduction of 82%.

This aligns with industry research suggesting that immersion cooling technology (compared with air cooling) can reduce water consumption by up to 89%<sup>5,6,7,</sup>. Equating to an average saving of over 3.5 million litres annually per data centre, and approximately 17.7m litres over 5 years<sup>8</sup>. 14

After transition





<sup>&</sup>lt;sup>5</sup>Henshaw, K. (2021) # 3 Metrics for Datacenter Efficiency: PUE, CUE, and WUE, Submer. Available at: https://submer.com/blog/pue-cue-and-wuewhat-do-these-three-metrics-represent-and-which-is-one-is-the-mostimportant/ (Accessed: 16 October 2024).

<sup>&</sup>lt;sup>6</sup>Hnayno, M. et al. (2023) Experimental investigation of a datacentre cooling system using a new single-phase immersion/liquid technique, ScienceDirect. Available at: https://www.sciencedirect.com/science/article/ pii/S2214157X23002319?ref=pdf\_download&fr=RR2&rr=88f968490afe385e (Accessed: 16 October 2024).

<sup>&</sup>lt;sup>7</sup>Barrowclough, N. (2023) Transforming data centre cooling for a sustainable future, Data Centre Magazine. Available at: https://datacentremagazine.com/ articles/transforming-data-centre-cooling-for-a-sustainable-future (Accessed: 16 October 2024).

<sup>&</sup>lt;sup>8</sup>Full calculations are on page 21.

### Chip manufacturers

In this study, chip manufacturers include semiconductor engineers, process engineers and semiconductor manufacturing technicians. This segment of the industry plays a major role in the data centre value chain, as their contributions impact efficiency, processing power and performance of all data centres.

The chip manufacturers in this research are preparing for a rise in immersion cooling, with four in five

### 81%

reporting a moderate or high market demand for chips that are optimised for immersion cooling.

### 87%

experiencing an uptick in customers requesting more products compatible with immersion cooling.

Many manufacturers themselves recognise the positive relationship between data centre performance and immersion cooling;

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### 57%

believe that immersion cooling will increase the reliability of chips.

75%

expect it to increase the lifespan of chips.

78%

of chip manufacturers see immersion cooling as offering improved chip performance.

77%

and compatibility with advanced technologies, addressing the concerns of both data centre owners and senior IT technicians.



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# THE RETURN ON IMMERSION



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If data centre experts accept that immersion cooling is the future industry standard - and are aware of the energy and resource savings it can deliver – the final question is: how much will this cost, and when will this investment pay off? At what point will businesses see a return on immersion?

### The financial incentive for change

Even if a facility is running efficiently, data centre managers stand to gain from transitioning their cooling technology as soon as possible; 77% of data centre experts in our research believe investment in immersion cooling will drive millions in returns for the industry, and three-quarters (74%) expect immersion cooling to reduce the total cost of data centre ownership compared with data centres that continue using air cooling systems.

The faster this change is initiated, the sooner the upfront cost can be tempered. The majority of respondents believe that data centre owners will see a return on their investment in immersion cooling in three years or less.

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# THE DIPPING POINT

### "...the industry must adopt immersion



Irrespective of the cost benefit, keeping pace with growing data centre power demand will require investment. The majority (76%) of data centre experts in our research believe that the industry must adopt immersion cooling within the next three years to continue to see performance improvements.

This aligns with data centre experts' anticipated rate of transition; they identify The Dipping Point – the year in which immersion cooling will become the dominant technology for data centre cooling – as 2027.

This prediction might be surprising given to date. Does this suggest organisations

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### within the next three years..."

research are correct and the industry is on the cusp of a rapid acceleration in implementation, organisations that are not already on track for widespread adoption may find themselves falling rapidly behind.

the relatively slow adoption in the industry "With the new wave of AI and high-density chips, electrical and mechanical systems are experimenting with immersion cooling are now intertwined. This intersection is

behind closed doors? If the experts in this crucial for vendors and solution providers; designing anything without considering both is no longer an option. The data centre industry needs to change its approach to temperature control, embracing new scalable, energy-efficient, compact and cost-effective solutions."

> Peter Huang, Global Vice President - Data Centre, Thermal Management, Castrol



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# HYPERSCALERS

### The future is now

Of all the organisations in this study, hyperscalers – data centres operated by large-scale cloud service providers, capable of delivering massive amounts of computing, storage, and networking resources to support global-scale applications and services – are the most likely to use immersion cooling. Two-thirds of these organisations (65%) are using or experimenting with immersion cooling in some capacity<sup>11</sup>.

There's a sense of urgency behind these high levels of adoption and experimentation; 27% of data centre experts at hyperscalers anticipate immersion cooling becoming the dominant technology in 2025, and 78% believe that immersion cooling is now the only option for data centres to meet the current compute power demand. Given their critical role in today's digital era, hyperscalers' backing of immersion cooling is a strong indicator of its future.

### The downside of downtime

However, service disruption is a major risk for these organisations. The cost of downtime emerges as a top consideration for a third of hyperscalers, amongst other concerns about the potential for fluid leakages and the time-consuming implementation. Naturally, hyperscalers are also cost conscious; 86% of those in our research expect that the upfront investment into immersion cooling will increase data centre ownership costs following transition. The same proportion also see the limited availability of immersion cooling components having the same effect. However, in the long-term, hyperscalers recognise that total ownership costs will come down again, especially due to reduced maintenance costs (84%) and the benefits of increased scalability (86%) from immersion cooling.

<sup>11</sup>This could include organisations using immersion cooling as a primary system, secondary system or in a single location as a proof-of-concept test

This report is based on data collected from external respondents, who we consider to be data centre experts, not from bp or its affiliates.



### TAKING THE IPLUNGE

This report is based on data collected from external respondents, who we consider to be data centre experts, not from bp or its affiliates. Immersion cooling can unlock a range of valuable benefits in data centres, leading experts to unanimously agree that it will become the industry's dominant technology in just a few years.

> Although organisations aren't currently committing to immersion cooling as a primary system, experts anticipate accelerated adoption is around the corner. And when data centre owners do adopt this technology, they trust that the return on immersion cooling will not be far away.

The accelerating pace of technological change is a growing threat to data centre performance and security, and it's up to owners and managers to protect their processors, their data and their business. Immersion cooling can help data centres stay ahead of the tide, unlocking higher capacity, extended lifespans, lower running costs and reduced resource consumption. Now, industry stakeholders must work together on testing, training, and system design and maintenance to prepare for *The* Dipping Point and enable the wider ecosystem to secure a Return on Immersion.









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# **IMETHODOLOGY**

The Dipping Point is based on an anonymous opinion research study amongst 600 data centre industry leaders, consisting of 510 data centre experts across mid-market and enterprise organisations and 90 chip manufacturers. Leaders were based in seven markets: the US, China, Germany, the Nordics, the UK, Canada, and Ireland. The study explores the barriers and accelerators to adopting immersion cooling in data centres, ultimately defining the pivotal role data centres will play in our future society.

#### **Opinion research**

The opinion research used CAWI (computer-assisted web interviewing) and was conducted between April and May 2024 in association with Coleman Parkes Research Limited and Man Bites Dog Limited, Thought Leadership Consultancy. The research was carried out under the ethical research guidelines set by both the MRS (Market Research Society) and ESOMAR (European Society for Opinion and Market Research). When this report refers to 'data centre experts' and 'chip manufacturers' throughout, it is solely referring to the individuals who took part in this opinion research.

#### **Audience:**

• 600 respondents overall

#### **Countries**:

- 100 US
- 100 China
- 100 Germany
- 100 the Nordics
- 100 UK
- 50 Canada
- 50 Ireland

#### Organisation type:

- 153 own or work with Hyperscaler data centres.
- 153 own or work with Colocation data centres.
- 102 own or work with Enterprise data centres.
- 51 own or work with Edge data centres.
- 51 own or work with Crypto data centres
- 90 chip manufacturers



#### **Definitions:**

- Hyperscaler data centres: Data centres operated
- by large-scale cloud service providers, capable of delivering massive amounts of computing, storage, and networking resources to support global-scale applications and services.
- Colocation data centres: Data centres where organisations rent space, power, and cooling infrastructure from a third-party provider, sharing the facility with other tenants while maintaining control over their own IT equipment.
- Enterprise data centres: Data centres owned and operated by individual organisations to support their internal IT infrastructure and services, typically located on the organisation's premises.
- Edge data centres: Data centres strategically positioned at the edge of a network, closer to end-users or IoT devices, to reduce latency and bandwidth usage for applications requiring real-time processing or data analysis.
- Crypto data centres: Data centres specifically designed to support the infrastructure and operations of cryptocurrency mining, trading, or blockchain-based applications.

#### Job role:

- 120 Data centre owners (including CIOs, CTOs, Head of/VP/SVP of Infrastructure)
- 180 Senior IT technicians (including Data Centre Technician, Network Technician)
- 210 Data centre designers (including Data Centre Architect, Data Centre Engineer, Data Centre Facility Manager, Infrastructure Project Manager, Mechanical Engineer, Electrical Engineer, Network Infrastructure Designer, Data Centre **Operations Specialist, Sustainability Specialist)**
- 90 chip manufacturers (including Semiconductor Engineers, Process Engineers and Semiconductor Manufacturing Technicians)

### **Organisation size:**

- On-premises / Crypto / Hyperscaler based on total data centre power capacity globally in megawatts (MW)
- 32 very small (500 KW 1 MW)
- 38 small (2 MW 3 MW)
- 162 medium (4 MW 5 MW)
- 104 large (6 MW 10 MW)
- 21 very large (11 MW +)
- Hyperscaler based on total data centre power capacity globally in gigawatts (GW):
- 142 1-10 GW
- 11 more than 10 GW
- Chip manufacturers based on annual production capacity of chips for data centre cooling systems
- 6 less than 100,000
- 15 between 100,000 and 500,000
- 14 between 500,000 and 1 million
- 22 between 1 million and 5 million
- 18 between 5 million and 10 million
- 6 between 10 million and 50 million
- 9 between 50 million and 100 million











### The resources in numbers: Calculations

In the 'resources in numbers' section of this report, we used rounded figures. The precise figures and calculations for energy and water consumption reduction are below:

### **Energy**:

- Of the data centres represented in this research, those that do not currently use immersion cooling consume, on average, 49529.72 MWhs of energy annually.
- For data centres that have already adopted immersion cooling to some extent, this figure drops to an average of 35387.89 MWh annually.
- This means a reduction of 14141.83 MWh, or 28.5%, calculated as follows:
- 49529.72 35387.89 = 14141.83 MWh. As a percentage, 14,141.83 of 49529.72 is 28.55%.
- To calculate energy savings over five years, we multiplied 14,141.83 by five, which equals 70,709.15 MWh.

#### Water:

- The data centres in this research reported consuming, on average, 3982500 litres of water annually before their adoption of immersion cooling.
- Industry research (as footnoted in the relevant 'resources) in numbers' section of this report) suggests that immersion cooling technology (compared to air cooling) can reduce water consumption by up to 89%.
- 89% of 3982500 is 3544425 litres. This means there is an average saving of 3544425 litres.
- To calculate this saving over five years, we multiplied 3544425 by five, which equals 17722125 litres.

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# //ABOUT CASTROL

Castrol, one of the world's leading lubricant brands, has a proud heritage of innovation and fuelling the dreams of pioneers. Our passion for performance, combined with a philosophy of working in partnership, has enabled Castrol to develop lubricants and greases that have been at the heart of numerous technological feats on land, air, sea, and space for over 125 years.

Castrol is part of the bp group and serves customers and consumers in the automotive, marine, industrial and energy sectors. Our branded products are recognised globally for innovation and high performance through our commitment to premium quality and cutting-edge technology.

For more information, please visit: **www.castrol.com** 

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