25th May 2018
Prague

MSAR® Technology - Emulsion Fuel for Power Generation, Marine Bunkers & Refinery Uses
Introduction to Quadrise

- Quadrise is the supplier of proprietary, proven MSAR® technology.
- A low viscosity “synthetic HFO” is produced by blending heavy residue streams without adding cutter, improving refinery margins.
- The technology and fuel are proven and verified at commercial scale.
- MSAR® emulsion fuels are used as direct substitutes for HFO in power and marine applications, and potentially refinery refuelling.
- Economic and environmental benefits for producer and consumer.
- IP is developed and protected jointly with Akzo Nobel and MSAR® projects are being developed with major global companies.
- QFI plc is listed on the London Stock Exchange (AIM companies).

MSAR® = Multiphase Superfine Atomised Residue
Quadrise licenses, operates & provides MSAR® technology, additives & services to produce a stable ‘Oil-in-Water’ emulsion fuel. How it works: Tiny droplets of extra-viscous heavy hydrocarbons are dispersed in water using proprietary processes and additives. Key benefits: ✓ Refinery yield improvement ✓ Water & chemicals replace cutters ✓ Blend ‘incompatible’ residue streams ✓ Simple, low risk implementation.

MSAR® provides refiners with low CAPEX, short cycle, upgrading solutions for HFO pool. Key benefits: ✓ Stable, lower cost fuel synthetic HFO ✓ Enhanced combustion & lower emissions (NOx, PM).

Delivers HFO consumers tangible cost savings & environmental benefits.

MSAR® stands for Multiphase Superfine Atomised Residue.
MSAR® Technology

Solid, viscous residues
✓ Refinery residue streams from VR to SDA pitch.
✓ Petchem reaction residues
✓ 1,000 – 100,000,000 cSt @ 100°C

Water ~29%
✓ Can be derived from utility, waste or stripped sour water sources

The blending hardware is based on proven asphalt emulsion systems. 100 units+ worldwide

1. Oil residues are taken direct from refinery rundown lines and cooled to achieve the required viscosity (~200-1000cSt @ 100-200°C typically) for the colloid mill.

2. Water, together with proprietary additives, is added to the residue in a high-speed colloid mill under pressure.

3. The mixture is processed in the mill and cooled to provide a highly stable oil-in-water fuel oil equivalent (~200cSt at 50°C) that can be run down to existing fuel oil tanks.
### Project Timeline

<table>
<thead>
<tr>
<th>1-2 months</th>
<th>3-4 months</th>
<th>6-12 months</th>
<th>Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scoping</strong></td>
<td><strong>Pilot Testing</strong></td>
<td><strong>FEED</strong></td>
<td><strong>EPC</strong></td>
</tr>
<tr>
<td>Refinery residue stream identified. Conceptual design and feasibility study.</td>
<td>Pilot testing at QRF*, additive formulation optimized based on end-use application and product specs.</td>
<td>Scope developed and a design prepared for implementation. Quadrise provide client training and experience.</td>
<td>Implementation/integration of MSAR® project in modular, scalable, containerised units.</td>
</tr>
</tbody>
</table>

**A 6KBPD MSAR® project costs ~$5m and is implemented within 12 months.**

*QRF = Quadrise Research Facility

**MSAR® installation at Cepsa San Roque Refinery**

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### MSAR® vs. HFO (RMG)

**Water**
- MSAR® contains ~30% water, resulting in a reduced calorific value compared to HFO.
- Typically 50% more fuel required (factored into economics).
- Water along with micro droplet size enhances the combustion process.

**Density**
- MSAR® density is higher as residue based.

**Viscosity**
- MSAR® Viscosity is lower as it is a function of the water in the bulk phase.

**Sulphur**
- Like HFO, MSAR® contains sulphur as a function of the residue.

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### Comparison of ISO8217:2010 marine residual fuel (RMG) versus MSAR®

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Limit</th>
<th>Category ISO-F-</th>
<th>ISO Test Method</th>
<th>Marine Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density at 15°C, kg/m³</td>
<td>max. 991,0</td>
<td>ISO 3675 / ISO 12185</td>
<td>1050,0</td>
<td></td>
</tr>
<tr>
<td>Kinematic Viscosity at 50°C, mm²</td>
<td>max. 380,0</td>
<td>ISO 3104</td>
<td>180,0*</td>
<td></td>
</tr>
<tr>
<td>Flash Point °C</td>
<td>min. 60</td>
<td>ISO 2719</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>Pour Point (upper)</td>
<td>max. 30</td>
<td>ISO 3016</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Winter Quality °C</td>
<td>max. 30</td>
<td>ISO 3016</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Summer Quality °C</td>
<td>max. 18</td>
<td>ISO 10370</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Carbon Residue, % (m/m)</td>
<td>max. 0,15</td>
<td>ISO 6245</td>
<td>0,3</td>
<td></td>
</tr>
<tr>
<td>Ash, % (m/m)</td>
<td>max. 0,5</td>
<td>ISO 3733</td>
<td>33,0</td>
<td></td>
</tr>
<tr>
<td>Water, % (v/v)</td>
<td>max. 3,5</td>
<td>ISO 14597 / 8754</td>
<td>3,5</td>
<td></td>
</tr>
<tr>
<td>Sulfur, % (m/m)</td>
<td>max. 2,5</td>
<td>ISO 14597 / 8754</td>
<td>2,5</td>
<td></td>
</tr>
<tr>
<td>Acid number, mg KOH/g</td>
<td>max. 2,0</td>
<td>IP 570 Part A</td>
<td>2,0</td>
<td></td>
</tr>
<tr>
<td>Hydrogen Sulphide, mg/kg</td>
<td>max. 350</td>
<td>ISO 14597 / IP 501</td>
<td>350</td>
<td></td>
</tr>
<tr>
<td>Vanadium, mg/kg</td>
<td>max. 100</td>
<td>ISO 14597 / IP 501</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Sodium, mg/kg</td>
<td>max. 0,10</td>
<td>ISO 10370-2</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Total Sediment Potential, % (m/m)</td>
<td>max. 0,10</td>
<td>ISO 10478</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Aluminium plus Silicon, mg/kg</td>
<td>max. 80</td>
<td>ISO 14597 / IP 501</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Used lubricating oil (ULO)</td>
<td>max*</td>
<td>IP 501/IP 470</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Zinc, mg/kg</td>
<td>max*</td>
<td>IP 501/IP 470</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Phosphorus, mg/kg</td>
<td>max*</td>
<td>IP 501/IP 470</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Calcium, mg/kg</td>
<td>max*</td>
<td>IP 501/IP 470</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

* The fuel shall be considered free of ULO if one or more elements Zn, P and Ca are below or at the specified limits. All three elements shall exceed the same limits before a fuel shall be deemed to contain ULO.

* = at 100s⁻¹
N/A = Not relevant for emulsion fuel
Economic drivers for MSAR®

Value is created via a significant refinery yield shift due to upgrading cutter from the fuel oil pool to the distillate pool.

Traditional refinery process

- 50% Refinery output
- 30% High value transport fuels
- 20% High value fuels used to dilute HFO
- 70% Residual fuels

Every barrel of high value premium fuel used to create HFO is lost margin to the refinery

HFO example
- 60% residue
- 40% diluent

An MSAR® refinery

- 70% Refinery output
- 30% MSAR®
- 70% Residue
- 30% Water & <1% chemicals

An additional 20% of higher value fuel can be sold by the refinery at the market rate vs HFO value

* Price of MSAR® < HFO on a per unit of energy basis
**Refinery economics (2H 18 example)**

**MSAR vs HFO = [ HFO value – distillate savings + additive costs ] x Net Calorific Value Adjustment**

<table>
<thead>
<tr>
<th>Generic Refinery Economics; Vacuum residue cut with LCO for 380cSt HFO vs Quadrise MSAR®</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MSAR® production per MSAR® Unit = 1000 mt/d</strong></td>
</tr>
<tr>
<td><strong>Market Prices (USD/MT)</strong></td>
</tr>
<tr>
<td><strong>Refinery Fuel Oil Blend Assumed</strong></td>
</tr>
<tr>
<td>Heavy Fuel Oil, 3.5wt% S</td>
</tr>
<tr>
<td>and... Refinery Residue</td>
</tr>
<tr>
<td><strong>MSAR® Blend Economics</strong></td>
</tr>
<tr>
<td>Refinery Residue</td>
</tr>
<tr>
<td>OPEX (Water 29%, Additives &lt;1%, etc)</td>
</tr>
<tr>
<td><strong>MSAR® Cost of Production (variable cost basis)</strong></td>
</tr>
<tr>
<td><strong>Assumptions:</strong> HFO NCV = 40.8 GJ/mt</td>
</tr>
<tr>
<td>Cost of MSAR® on HFO basis = 40.8 / 27.1</td>
</tr>
<tr>
<td>Margin for MSAR® vs HFO (normalised for NCV)</td>
</tr>
<tr>
<td>($129/m3 HFO x 27.1 / 40.8)</td>
</tr>
</tbody>
</table>

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**Step 1:** Derive the value of the residue per ton, based on value of HFO less the cost of distillates (LCO)

**Step 2:** Calculate the cost of MSAR® (residue + water + additives)

**Step 3:** Adjust for lower calorific value and compare savings “like for like” vs HFO.

**Step 4:** MSAR® value to be shared, (assumed 50% to refinery)...
• Positive for QFI and the MSAR® fuel solution:
  • Wider distillate – fuel oil ‘spreads’ create even stronger economics.
  • High margins combined with low CAPEX, <$5million for 6KBPD MSAR®, and quick implementation, <12mths, result in <2 year payback providing low risk, short cycle projects.
• MSAR® is compatible with ECGS (“scrubber”) so positive for End Users with EGCS as it enables affordable compliance with environmental standards.
• MSAR® can be both a permanent or interim solution based on other upgrading projects.
Economic & Environmental Benefits

**1. Energy Savings**
- MSAR® is stored & transported at ambient temperatures (>25°C)

**2. Efficient Combustion**
- Complete Carbon burnout = lower dust emissions = less Black Carbon

**3. Lower NOx Emissions**
- Water reduces the combustion temperature = >20% lower NOx emitted

**4. Lower CO₂ Impact**
- Considerable CO₂ emission savings of 6% CO₂ using EGCS vs. <0.5%S fuel.

Source: Concawe Report 1/13R (EU Refineries) 2013
Cepsa MSAR® Installation

- 6 KBPD MSAR® system installed at the CEPSA 240 KBPD Gibraltar San Roque Refinery for Marine & Power
- Quadrise responsible for MSAR® system installation, commissioning, operations & quality control
- MSAR® system designed to supply Marine or Power end users, installed in 9 months for <$5m
- Processing visbreaker residue from a wide range of sweet and sour opportunity crudes
- Proven, reliable, 24/7, continuous operation
Our Focus on HFO Applications

Steam Boilers (Power & Utilities)

- Significant worldwide emulsion fuel boiler experience.
- Experience applied to MSAR® improvements.
- >60 million tons emulsion fuel fired: 50MWth to 770MWe

Plus Cement Kilns, Fired Heaters etc...

Diesel Engines (Marine & Power)

- MSAR® is proven in Wärtsilä 4-stroke diesel engines.
- JDA with Maersk commenced in 2008 to demonstrate MSAR® use in large 2-stoke diesel propulsion engines.
- Successful laboratory and land-based tests (2009-2013) leading to sea-borne 2014 “Proof of Concept” vessel tests.
- “Operational LONO Trial” with Cepsa & Maersk 2016/17.
- Interim LONO received from Wärtsilä for Flex Engine Types.
**Global Applications Summary**

**Complementary Solutions**
- Refinery heaters and boilers.
- National Oil Company synergies to provide MSAR® for Marine & Power.
- Selected upstream & petrochemical residue opportunities.

**Power**
- Opportunities for KSA PowerGen supply 400-500KBPD HFO.
- MoA signed with JGC Corporation to develop MSAR® projects in Japan and elsewhere.
- Supply into Middle East, Asia etc.
- Potential funding of emissions control equipment.

**Marine**
- Term supply options with bunker buyers to further improve scrubber economics.
- OEM (MAN & Wärtsilä) approvals for MSAR® use alongside scrubbers.
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Thank you / Děkuji - questions welcome!

Further info available:
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