Corrosion inhibitors for Oilfield applications
Unleash the full potential of your corrosion inhibitor formulations

Nouryon has a long history of supplying the Oil- and Gas Industry with efficient and reliable corrosion inhibitor bases for multiple uses. With our wide portfolio of surfactants and polymers, deep organic and surface chemistry knowledge, sustainability focus, regulatory expertise and global footprint, we can help you all the way from the design of your formulation to the final use of your product.

Our offering includes a range of base inhibitors (Armohib CI series), the heart of the formulation, as well as a number of versatile co-inhibitors and/or co-surfactants. Most of these are based on amine chemistry, but also e.g. phosphate ester based enhancers are available. Some of the co-inhibitors may also be used as primary inhibitors for special cases outside the upstream oilfield area, like in high-temperature environments such as refineries or boilers/condensers in Water Treatment systems. In addition, we provide formulation aids and wetting agents, ideal to resolve compatibility challenges or top-up the integrity or performance of your formulations. More over, we supply highly efficient proprietary blends for HCl- or organic acid inhibition.

This brochure features a deep-dive into some of our Armohib CI products as well as an overview table showing our offering in the area. A selection guide is provided below, as well as some formulation examples and selected performance data.

Want to know more ? Ask us !

Armohib® CI-219

highest standard imidazoline corrosion inhibitor

Imidazoline chemistry is the basis for one of the dominating type of film-forming organic corrosion inhibitors for oil- and gas installations globally. With Armohib CI-219, Nouryon offers a superior quality Tall Oil Fatty Acid (TOFA) imidazoline.

Features
- High imidazoline contents, >70%
- Flexible solubility profile for different purposes by organic acid addition
- Easy to handle, clear liquid at room temperature, and with a pour point well below -15°C
- High film persistence independently proven by AFM measurements
- Laboratory validated excellent sour corrosion inhibition performance for low salinity brines and moderate temperatures

Recommended uses
- For low- and middle range temperature oil- and gas recovery, treatment or transport scenarios
- Formulated as oil soluble, oil soluble-water dispersible or water soluble-oil dispersible depending on requirement of the specific application
- Formulation with enhancers such as Na-thiosulfate is possible and will boost performance versus sweet corrosion further

Formulation and performance examples

Water based, high Fp, high neutralization

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armohib CI-219</td>
<td>24%</td>
</tr>
<tr>
<td>GAA</td>
<td>10%</td>
</tr>
<tr>
<td>Water soluble up to 100%</td>
<td></td>
</tr>
</tbody>
</table>

The pH (2% in water) of this water soluble/oil dispersible formulation will be around 5.0.

Solvent based, for gas pipelines, etc

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armohib CI-219</td>
<td>15%</td>
</tr>
<tr>
<td>Diethanol amine</td>
<td>15%</td>
</tr>
<tr>
<td>GAA</td>
<td>10%</td>
</tr>
<tr>
<td>Aromatic solvent</td>
<td>up to 30%</td>
</tr>
</tbody>
</table>

For these types of systems, a soluble amine should ideally be mixed with a water dispersible film-forming amine.

Selection guide

Water dispersible film forming amine.

High T is High Temp

The pH (2% in water) of this water soluble-oil dispersible formulation will be around 5.0.

recommended uses

- For low- and middle range temperature oil- and gas recovery, treatment or transport scenarios
- Formulated as oil soluble, oil soluble-water dispersible or water soluble-oil dispersible depending on requirement of the specific application
- Formulation with enhancers such as Na-thiosulfate is possible and will boost performance versus sweet corrosion further

Armohib CI-209

Armohib CI-209 is a variant of CI-219 based on regionally sourced raw materials, can be applied the same way.

Concentrations in the formulation examples are indicated in weight percent
GAA is Glacial Acetic Acid
80C is Butyl diglycol
When reference is made to “water”, this refers to soft water
Other water qualities may require formulation modifications

High imidazoline content, can be formulated to meet various harsh corrosion challenges
Armohib® CI-5150
for exemplary corrosion control

With unique chemistry, Armohib CI-5150 meets today’s strictest environmental requirements and is extremely easy to use.

Technology
This novel corrosion inhibitor technology has been developed by Nouryon specifically for use in the oilfield. It is designed to maintain exemplary corrosion control compared with industry standards, whilst having clearly improved ecotoxicity characteristics. This allows the material to be used in environmentally sensitive offshore marine locations.

The unique, patented film-forming alkyl polyquaternary amine-based chemistry display multiple positive-charge functionality along the polymer chain providing several points of adhesion to the metal surface, giving great film integrity under various conditions. In addition, this chemistry results in first class brine compatibility. Armohib CI-5150 demonstrates excellent oil to brine partitioning in discrete phase laboratory tests, currently involving data up to +80°C and above.

Recommended uses
• Sweet corrosion / pipeline applications
• Severe brine environments
• Corrosion control in environmentally sensitive oilfield production applications
• Topside or umbilical-fed production systems that require film-forming corrosion control
• Formulated in various organic systems or in aqueous systems for ease of use and/or minimized cost/performance profile
• High flashpoint blends as well as methanol-based formulations for extremely cold conditions can be recommended
• Use in alkaline water-based formulations is not recommended

Regulatory information
Armohib CI-5150 is REACH and TSCA compliant. In addition the product is approved for all parts of the North Sea as well as any other region applying OSPAR regulations. It is classified WGK1 in Germany (water hazard class).

Features
• Excellent sweet corrosion inhibiting properties when tested under standard conditions and against benchmark chemistries, 99.8% protection at 1 ppm dosage in a non-optimized formulation demonstrated
• Corrosion reduction of >99% at 10 ppm dosage demonstrated in RCE (30 Pa wall shear stress) tests, indicating stable performance also under high flow conditions (data obtained in 3% NaCl brine at +60°C)
• Compatible with heavy brines as e.g. 26% NaCl, 20% NaCl at +70°C, >30% CaCl₂ and 50 000 ppm Ca/25 000 ppm Na brine at +80°C
• Promising performance also for organic acid inhibition at elevated temperature, e.g. >95% protection of carbon steel in 10% citric acid after 24h at +95°C
• Low order of ecotoxicity, making the product suitable for use in the most stringent regulatory environments
• Aqua-toxicity 10-100 times lower than for common oilfield CI bases such as benzalkonium chlorides and imidazolines, no dangerous to the environment label
• Testing has shown CI-5150 is not skin irritating, sensitizing or mutagenic
• Easy to handle, being a clear liquid at room temperature
• In-house formulation studies have shown the active material to be extremely flexible when formulated, allowing the chemist to develop both aqueous and solvent based corrosion inhibitor solutions, including with environmentally acceptable solvents
• Formulated in various organic systems or in aqueous systems for ease of use and/or minimized cost/performance profile
• High flashpoint blends as well as methanol-based formulations for extremely cold conditions can be recommended
• Use in alkaline water-based formulations is not recommended

Armohib® CI-5174
a versatile corrosion inhibitor

Armohib CI-5174 is an innovative, polymeric amine for cutting edge formulations.

Technology
This novel corrosion inhibitor technology, developed by Nouryon specifically for use in the oilfield, has been designed to maintain exemplary corrosion control while offering versatile functionality and highest ease of handling, allowing the material to be used in a variety of formulation alternatives.

The film-forming alkyl polyamine-based chemistry results in multiple heteroatom functionality along the polymer chain, which is believed to enable several points of adhesion to the metal surface giving greater film integrity under various conditions. Feedback from the field indicates a maintained level of corrosion protection in spite of lower dosage levels and longer intervals between dosage compared to previously used chemistry.

Armohib CI-5174 demonstrates excellent oil to brine partitioning in discrete phase laboratory tests and distribution properties can easily be tuned by modifying the solubility profile, for example by adding acetic acid.

Recommended uses
• Sweet and sour corrosion / pipeline applications
• Topside or umbilical-fed production systems that require film-forming corrosion control
• Corrosion applications where turbulent fluid flow compromise film integrity leading to excess corrosion rates or and/or high dosage of standard active inhibitor
• Formulated in various organic solvents or in aqueous systems for ease of use and optimized cost/performance profile
• High flashpoint blends as well as methanol-based formulations for extremely cold conditions and/or umbilical application can be recommended

Features
• Excellent sweet corrosion inhibiting properties when tested under standard conditions and against benchmark chemistries, 99.4% protection at 1 ppm dosage in a non-optimized formulation demonstrated
• Compatible with base inhibitor synergists such as Na-thiosulfate
• Combined H₂S- and CO₂-corrosion inhibitor
• Protective film integrity also under high flow conditions demonstrated by RCE testing, where a 10 ppm active inhibitor dosage yielded 99% protection at 30 Pa wall shear stress (data obtained in 3% NaCl brine at +60°C)
• Easy to handle, being a clear liquid at room temperature and having a pour-point of -12°C
• A significantly lower foam profile than e.g. alkyl benzalkonium chlorides and fatty acid imidazoline acetates
## Corrosion inhibitors offering overview

<table>
<thead>
<tr>
<th>Corrosion Inhibitors</th>
<th>Physical form</th>
<th>Chemistry</th>
<th>Active content</th>
<th>Pour point °C</th>
<th>Viscosity mPa.s/25°C</th>
<th>Flash point °C</th>
<th>Foam mm²/5 min</th>
<th>Surface tension mN/m</th>
<th>SOLUBILITY Water/ Methanol/IPA</th>
<th>Aliphatic solvent</th>
<th>Aromatic solvent</th>
<th>Diesel</th>
<th>FUNCTIONALITY &amp; USE</th>
<th>REGULATORY DATA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Corrosion Inhibitors</td>
<td>Armohib CI-26</td>
<td>Liquid</td>
<td>Proprietary surfactant blend</td>
<td>-</td>
<td>11</td>
<td>32</td>
<td>-</td>
<td>- - - -</td>
<td>D S S S S S S</td>
<td>Gen Cl, pipeline, gas etc</td>
<td>Flexible for oil / water</td>
<td>-</td>
<td>Yes</td>
<td>-</td>
</tr>
<tr>
<td>Armohib CI-33</td>
<td>Liquid</td>
<td>Proprietary surfactant blend</td>
<td>-</td>
<td>0</td>
<td>- &gt;150</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Organic acids inhibitor</td>
<td>Add to acid solution</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Imidazolines</td>
<td>Armohib CI-41</td>
<td>Liquid</td>
<td>Polyamine + TIPA imidazole</td>
<td>100%</td>
<td>-0</td>
<td>800</td>
<td>&gt;218</td>
<td>-</td>
<td>-</td>
<td>D S S S S S S</td>
<td>Gen Cl, pipeline, gas etc</td>
<td>Flexible for oil / water</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Armohib CI-209*</td>
<td>Liquid</td>
<td>DETA + TIPA-imidazole</td>
<td>100%</td>
<td>-&lt;15</td>
<td>20</td>
<td>&gt;93</td>
<td>11*</td>
<td>-</td>
<td>-</td>
<td>D S S S S S S</td>
<td>Gen Cl, pipeline, gas etc</td>
<td>Flexible for oil / water</td>
<td>High imidazoline cont</td>
<td>-</td>
</tr>
<tr>
<td>Armohib CI-219</td>
<td>Liquid</td>
<td>DETA + TIPA-imidazole</td>
<td>100%</td>
<td>-&lt;15</td>
<td>20</td>
<td>&gt;125</td>
<td>10.5-12.5*</td>
<td>-</td>
<td>-</td>
<td>D S S S S S S</td>
<td>Gen Cl, pipeline, gas etc</td>
<td>Flexible for oil / water</td>
<td>High imidazoline cont</td>
<td>-</td>
</tr>
<tr>
<td>Armohib CI-300</td>
<td>Liquid</td>
<td>TIPA + TIPA imidazole</td>
<td>100%</td>
<td>-7</td>
<td>43</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>D S S S S S S</td>
<td>Gen Cl, pipeline, gas etc</td>
<td>Flexible for oil / water</td>
<td>-</td>
<td>Yes</td>
</tr>
<tr>
<td>Polymeric Corrosion Inhibitors</td>
<td>Armohib CI-5150</td>
<td>Liquid</td>
<td>Polymeric Ether Quat</td>
<td>55% (in BDG)</td>
<td>-5</td>
<td>3500</td>
<td>90-94</td>
<td>3.4-4.1</td>
<td>125/102</td>
<td>31</td>
<td>S S D S S S S</td>
<td>Gen Cl, regulated areas</td>
<td>Outstanding</td>
<td>Excellent brine tolerance</td>
</tr>
<tr>
<td>Armohib CI-5127</td>
<td>Liquid</td>
<td>Polymeric Ether Amine</td>
<td>100%</td>
<td>-12</td>
<td>1185</td>
<td>&gt;200</td>
<td>7-8</td>
<td>25/0</td>
<td>-</td>
<td>S S S S I I</td>
<td>Gen Cl, sweetness corrosion</td>
<td>Flexible for oil / water</td>
<td>Good brine tolerance</td>
<td>No</td>
</tr>
<tr>
<td>Amine and Diamines</td>
<td>Armohib C</td>
<td>Liquid</td>
<td>C6-coco alkylamine</td>
<td>100%</td>
<td>nd</td>
<td>4 (g/b)</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
<td>P nd S nd S S nd</td>
<td>Sec inhibitor, formul aid</td>
<td>Often used as acid salt</td>
<td>-</td>
<td>Yes</td>
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<tr>
<td>Duomeen C</td>
<td>Paste</td>
<td>N-coco-1,3-diaminopropane</td>
<td>100%</td>
<td>nd</td>
<td>4 (g/b)</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
<td>P nd S nd D nd</td>
<td>Sec inhibitor, formul aid</td>
<td>Often used as acid salt</td>
<td>Bicocide for fracking (US)</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Duomeen D</td>
<td>Paste</td>
<td>N-oleyl-1,3-diaminopropane</td>
<td>100%</td>
<td>nd</td>
<td>11 (g/b)</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
<td>D nd S nd S nd</td>
<td>Sec inhibitor, formul aid</td>
<td>-</td>
<td>HT stable for boiler, refinery</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Duomeen T</td>
<td>Paste</td>
<td>N-tallow-1,3-diaminopropane</td>
<td>100%</td>
<td>nd</td>
<td>6 (g/b)</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
<td>D nd S nd P D nd</td>
<td>Sec inhibitor, formul aid</td>
<td>-</td>
<td>HT stable</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethoxylated Amines and Diamines</td>
<td>Ethomeen CI-32</td>
<td>Liquid</td>
<td>Coco alkylamine + 2 EO</td>
<td>100%</td>
<td>8</td>
<td>nd</td>
<td>193</td>
<td>-</td>
<td>-</td>
<td>D nd S S S S D nd</td>
<td>Sec inhibitor, formul aid</td>
<td>-</td>
<td>Cleaning</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethomeen CI-35</td>
<td>Liquid</td>
<td>Coco alkylamine + 3 EO</td>
<td>100%</td>
<td>-S</td>
<td>15</td>
<td>&gt;100</td>
<td>9-11</td>
<td>100/70</td>
<td>30</td>
<td>S S S S D S S</td>
<td>Sec inhibitor, formul aid</td>
<td>Water soluble</td>
<td>Cleaning</td>
<td>Yes</td>
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<tr>
<td>Ethomeen CI-25</td>
<td>Liquid</td>
<td>Coco alkylamine + 15 EO</td>
<td>100%</td>
<td>-&lt;0</td>
<td>210</td>
<td>&gt;100</td>
<td>9-11</td>
<td>10/5</td>
<td>38</td>
<td>S S S S</td>
<td>Sec inhibitor, formul aid</td>
<td>Water soluble</td>
<td>Dispersion, Cleaning</td>
<td>Yes</td>
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<tr>
<td>Ethomeen CI-12</td>
<td>Liquid</td>
<td>Oleyl alkylamine + 2 EO</td>
<td>100%</td>
<td>1</td>
<td>150</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
<td>D nd</td>
<td>Sec inhibitor, formul aid</td>
<td>Oil soluble, liquid</td>
<td>Acidic cleaning</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Ethomeen T/12</td>
<td>Paste</td>
<td>Tallow alkylamine + 2 EO</td>
<td>100%</td>
<td>32</td>
<td>34 (g/b)</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
<td>D nd</td>
<td>Sec inhibitor, formul aid</td>
<td>Oil soluble</td>
<td>Acidic cleaning</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethomeen T/15</td>
<td>Paste</td>
<td>Tallow alkylamine + 5 EO</td>
<td>100%</td>
<td>8</td>
<td>160</td>
<td>&gt;100</td>
<td>10</td>
<td>35/35</td>
<td>31</td>
<td>S nd S nd S S S</td>
<td>Sec inhibitor, formul aid</td>
<td>-</td>
<td>HT stable</td>
<td>Yes</td>
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<tr>
<td>Ethomeen T/25</td>
<td>Paste</td>
<td>Tallow alkylamine + 15 EO</td>
<td>100%</td>
<td>5</td>
<td>310</td>
<td>&gt;100</td>
<td>9-11</td>
<td>55/15</td>
<td>39</td>
<td>S S S S I I I</td>
<td>Sec inhibitor, formul aid</td>
<td>Water soluble, liquid</td>
<td>HT stable, Cleaning</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethomeen T/31</td>
<td>Paste</td>
<td>Tallow alkyl dianine + 3 EO</td>
<td>100%</td>
<td>20</td>
<td>950</td>
<td>&gt;100</td>
<td>-</td>
<td>-</td>
<td>D S S S S S S</td>
<td>Sec inhibitor, formul aid</td>
<td>Water soluble</td>
<td>HT stable</td>
<td>Cleaning</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethomeen T/22</td>
<td>Paste</td>
<td>Tallow alkyl diamine + 12 EO</td>
<td>100%</td>
<td>-8</td>
<td>360</td>
<td>&gt;100</td>
<td>100/35</td>
<td>38</td>
<td>S S S S I I I</td>
<td>Sec inhibitor, formul aid</td>
<td>Good brine tolerance</td>
<td>HT stable for boiler, refinery</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ethoxylated Quats</td>
<td>Ethoclad C12</td>
<td>Liquid</td>
<td>C6-coco alkylmethyammonium chloride + 15 EO</td>
<td>&gt;95%</td>
<td>15</td>
<td>1150 (pH25)</td>
<td>127</td>
<td>6-8</td>
<td>nd</td>
<td>43</td>
<td>S S S S I D</td>
<td>I</td>
<td>High temp / High brine</td>
<td>Acid intensifier</td>
</tr>
<tr>
<td>Ethoclad O12 PG</td>
<td>Liquid</td>
<td>C6-octyl methyammonium chloride + 2 EO</td>
<td>69% (in PG)</td>
<td>nd</td>
<td>10</td>
<td>6-8</td>
<td>nd</td>
<td>40</td>
<td>S S S S D D</td>
<td>D</td>
<td>High temp / High brine</td>
<td>Acid intensifier</td>
<td>Good brine tolerance</td>
<td>Yes</td>
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<tr>
<td>Benzyl Quats</td>
<td>Arquad MCB-50</td>
<td>Liquid</td>
<td>C6-cocoalkyl dimethyl ammonium chloride</td>
<td>50% (in water)</td>
<td>nd</td>
<td>130</td>
<td>&gt;60</td>
<td>6-9 (10%)</td>
<td>89/88</td>
<td>S nd S nd nd nd nd</td>
<td>Sec inhibitor</td>
<td>Water soluble</td>
<td>-</td>
<td>Yes</td>
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<tr>
<td>Arquad HTB-75</td>
<td>Paste</td>
<td>Vegetable oil benzyl dimethyl ammonium chloride</td>
<td>75% (in IPA/ water)</td>
<td>nd</td>
<td>65 (g/b)</td>
<td>31</td>
<td>6-9</td>
<td>-</td>
<td>-</td>
<td>nd nd nd nd nd nd</td>
<td>Sec inhibitor</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Phosphate Esters</td>
<td>Phospholan P65</td>
<td>Liquid</td>
<td>Alkyl Phosphate Ester, Free Acid</td>
<td>99%</td>
<td>-12</td>
<td>1985</td>
<td>&gt;150</td>
<td>2-3</td>
<td>10/8</td>
<td>-</td>
<td>D S S S S S S</td>
<td>Inhibition booster</td>
<td>Flexible for oil / water</td>
<td>Oxygen corrosion inhibition</td>
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<tr>
<td>Formulation aids and Wetting agent</td>
<td>Armoclean 4350</td>
<td>Liquid</td>
<td>Alcohol alkoxylate</td>
<td>100%</td>
<td>-9</td>
<td>30</td>
<td>&gt;100</td>
<td>7-9</td>
<td>5/0</td>
<td>27</td>
<td>S S S S S S</td>
<td>Wetting agent</td>
<td>Broad</td>
<td>Cleaning</td>
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<tr>
<td>Armoclean 6000</td>
<td>Liquid</td>
<td>Alkyl glucoside</td>
<td>65% (in water)</td>
<td>nd</td>
<td>160 (g/b)</td>
<td>6-8</td>
<td>8/0</td>
<td>33</td>
<td>S nd I nd I I nd</td>
<td>Formul aid/ surfactant</td>
<td>Water based formulations</td>
<td>Excellent brine tolerance</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Armoclean 6040</td>
<td>Liquid</td>
<td>Alkyl glucoside</td>
<td>75% (in water)</td>
<td>-7</td>
<td>775</td>
<td>&gt;60</td>
<td>7-8</td>
<td>nd</td>
<td>34</td>
<td>D nd I nd I I nd</td>
<td>Formul aid/ surfactant</td>
<td>Water based formulations</td>
<td>Excellent brine tolerance</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* = regional Americas variant of CI-219
nd = no data
BDG = Butyl diglycol
IPA = Isopropyl alcohol
$^{+3}$% in 3.1 IPA/water
$^{+1.5}$% in 80/20 water/IPA
IPA @ +40°C
* = soluble
D = dispersable
P = pastel/gel
Gen = general
Sec = secondary
HT = high temp (>120°C)
Apvd = approved
OSPAR = OSPAR
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