Subsea oil and gas operations are moving into deeper water and tapping reservoirs well below the seafloor. Handling production with much higher pressures and hotter temperatures in cold waters demands balancing risks between capex and opex. Extended equipment life and optimized flow are critical. More reliable, cost-efficient, and lower-risk thermal insulation is needed to maintain flow in the pipes above the hydrate formation and wax appearance temperatures to prevent blockages and to provide sufficient no-touch time for troubleshooting during shutdowns.

Advanced subsea wet insulation systems based on solid silicone science may be a viable option to syntactic foams or syntactic silicones, as well as to wet insulation systems based on polyurethane, epoxy, polyether, phenolic, or specialized polymers.

A new engineered thermal insulation solution is being introduced to help meet the flow assurance needs of subsea oil and gas operations. Formulated with silicone expertise, application experience, and industry collaboration, the proposed advanced technology from Dow Corning Corp. for subsea wet insulation systems uses a solid silicone, unlike syntactic foams or silicone resins that contain glass microspheres.

Developed to insulate high-pressure/high-temperature (HP/HT) equipment used in deep-water production infrastructure and tiebacks, the new XTI-1003 RTV Silicone Rubber Insulation potentially offers several advantages. Ongoing tests of performance compared to producer specifications and applicator requirements indicate improvements such as: simplicity of use; ease of application; increased joint strength; excellent flexibility; thermal stability; and anticipated gains in field performance, reliability, and service life.

Solid silicone science

The company’s new product, the XTI-1003 RTV Silicone Rubber Insulation system, is a two-part, high-strength silicone rubber for subsea wet insulation. It is designed to assist in providing more reliability, added cost-efficiency, and reduced performance risks in harsh subsea environments. The non-syntactic technology does not use glass microspheres while emphasizing joint strength and resistance to extreme pressures.

Based on room-temperature-curing (RTV), liquid silicone rubber (LSR) elastomer is easy to mix and apply. It cures to a durable, flexible, translucent rubber without potentially harmful by-products. Projected insulation performance advantages, as well as coating-application benefits, are:

- Thermal stability across a wide temperature range
- Good insulating properties for longer no-touch times
- Excellent flexibility and resistance to cracking
- Reduced degradation with less potential for water ingress
- Easier processing for curved, straight-

### Results of Extended Aging Testing

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>TEST TEMPERATURE</th>
<th>120°C</th>
<th>135°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss, %</td>
<td>INITIAL</td>
<td>60 DAY</td>
<td>90 DAY</td>
</tr>
<tr>
<td>Durometer, Shore A</td>
<td>39</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>Tensile strength, MPa</td>
<td>6.4</td>
<td>6.3</td>
<td>6.2</td>
</tr>
<tr>
<td>Elongation, %</td>
<td>364</td>
<td>160</td>
<td>160</td>
</tr>
</tbody>
</table>

Exposure of ASTM tensile specimens are subjected to wet heat aging at specified temperatures in a 3% NaCl seawater mixture to observe accelerated aging characteristics. Samples were characterized at monthly intervals throughout the six-month study.

NOTE: Contact Dow Corning for information about ongoing temperature testing.

Example of solid silicone insulation application. (Photo courtesy Trelleborg Offshore UK Ltd.)
line, and flexible sections
• Durable joint integrity with silicone-to-
silicone bonding
• Fast addition-reaction cure in unlimited
thickness that can be accelerated with heat.

In providing a simple, yet robust, subsea
wet insulation system, XTI-1003 RTV can
help optimize flow assurance and manage
risks on HP/HT subsea production architec-
ture from wellheads to tieback components.

Potential applications for the new silicone
insulation systems could include:
• Wellheads
• Subsea trees
• Pipeline end manifolds (PLEMs)
• Pipeline end terminations (PLETs)
• Jumpers and spoolpieces
• Sleds
• Flowline ends and riser ends
• Flange connections.

### Performance profile

Compared to the Silastic E RTV silicone
rubber used in earlier syntactic thermal insu-
lation systems, XTI-1003 RTV exhibits a num-
ber of improvements as a solid silicone wet in-
sulation system. These include advancements
in flexibility, joint bonding, tear strength,
and elongation, which show improved high-
temperature performance. This non-syntactic
silicone rubber also has better resistance to
degradation by reducing potential for water
ingress at elevated temperatures. This is an
advantage compared with syntactic insulation,
which may have voids from microsphere col-
lapse as a result of subsea pressure.

For deepwater subsea applications, typi-
cal wet insulation is molded directly around
the equipment with no need for an outer pro-
tective jacket. The insulation is exposed di-
rectly to the cold seawater on the outer sur-
face, with the inner surface exposed to the
high-temperature fluids flow. Critical design
parameters are thermal conductivity, insu-
lation thickness, and specific heat capacity.

Primary concerns are resistance to degrada-
tion, high-temperature stability, and physical
durability in both equipment deployment
and saltwater production operations. The silicone rubber insulation exhibits the fol-
lowing physical properties when cured:
• Specific gravity: 1.08
• Durometer hardness: 40
• Tensile strength: 5.5 MPa
• Elongation: 400%
• Thermal conductivity (dry): 0.196 W/mK
• Thermal conductivity (aged, wet): 0.201
W/mK
• Specific heat capacity at 135°C: 1.79 J/g/°C.

In a 45° bonding study during which
material was cast over a two-day period to
simulate actual insulation application on
subsea equipment, excellent silicone-to-
silicone bond strength was achieved. This
underscores the capability of the new tech-
nology to establish strong joint integrity
that can withstand deepwater pressures and
equipment movement. With the high tensile
strength and elongation demonstrated dur-
ing testing, excellent joint strength in both
rigid and flexible sections is possible.

In testing by an insulation coating special-
ist in conjunction with an independent lab,
the low thermal conductivity of XTI-1003
RTV was verified. Qualification require-
ments have been met for process tempera-
tures up to 115°C (239°F), and ongoing test-
ing is expected to certify the technology for
applications to 135°C (275°F) and possibly
to 150°C (302°F) or higher.

Further independent testing under specific
application conditions has helped verify claims
for durability, thermal stability, and excellent
silicone-to-silicone adhesion. Cured samples
of the new solid silicone insulation were tested
for extended intervals, both submerged and
exposed to elevated temperatures. Perform-
ance was documented at 120°C, 135°C and
150°C, and results at the higher temperatures
indicated improved performance over sili-
cones used in syntactic systems.

The silicone rubber insulation performed
well in simulated service tests, extended
service tests, and arctic conditions testing.
Extensive 150°C heat-aging testing also was
conducted and is being validated indepen-
dently with further extended testing.

### Simplicity reduces risks

Even with its performance during testing,
this new silicone rubber insulation still must
be applied properly and professionally. Expe-
rienced coating specialists are responsible
for prescribed application techniques and proce-
dures. Here, the technology adds a measure of
application ease to reduce risks of inadequate
adhesion or inconsistent joint integrity.

Typically, the most practical application
methods for insulating complex-shaped com-
ponents with this solid silicone thermal insulation
system will be cast in place, pre-cast, or bonded
to itself on metal components. Since subsea
metal components can have various corrosion
coatings, a primer usually is recommended to
ensure maximum insulation adhesion.

Supplied as a two-part system, the low-vis-
cosity silicone rubber base and curing agent
are mixed in a 10:1 ratio and then pumped
into the mold using conventional equipment.
Care must be taken to avoid excessive air
entrapment, so applicators should fill molds
from the bottom up and provide sufficient
air vents toward the top of molds.

Once mixed, XTI-1003 RTV has a working
time of approximately 90 minutes at a mod-
erate temperature (23°C, or 73°F). The addi-
tion-reaction cure (polymerization) typically
requires up to 12 hours at room temperature
before demolding, or the material may need
to be heated. Curing will accelerate in warm-
er temperatures. If the insulation is being
cast in lower temperatures, up to 24 hours
may be needed before molds are removed.

Dow Corning is working with insulation
coating specialists to establish application pro-
cesses and quality-control procedures for this
technology. Equipment-specifying producers
would contract these specialists to meet their
equipment thermal insulation requirements.