MAXIMUM RECOMMENDED ELEMENT TEMPERATURES IN ATMOSPHERES

<table>
<thead>
<tr>
<th>Atmosphere</th>
<th>MD-31</th>
<th>MD-33</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>°C</td>
<td>°C</td>
</tr>
<tr>
<td>Air</td>
<td>1700</td>
<td>3090</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>1600</td>
<td>2910</td>
</tr>
<tr>
<td>Argon, helium</td>
<td>1600</td>
<td>2910</td>
</tr>
<tr>
<td>Dry Hydrogen, dewpoint -80ºC (-112ºF)</td>
<td>1150</td>
<td>2100</td>
</tr>
<tr>
<td>Moist hydrogen, dewpoint 20ºC (68ºF)</td>
<td>1450</td>
<td>2640</td>
</tr>
<tr>
<td>Exogas (e.g. 10% CO₂, 5% CO, 15% H₂)</td>
<td>1600</td>
<td>2910</td>
</tr>
<tr>
<td>Endogas (e.g. 40% H₂, 20% CO)</td>
<td>1400</td>
<td>2550</td>
</tr>
<tr>
<td>Cracked and partially burnt ammonia (≈8%H₂)</td>
<td>1400</td>
<td>2550</td>
</tr>
</tbody>
</table>

Note: For maximum recommended element temperatures in a vacuum, see graph below

Permissible Atmospheres
MOLY-D heating elements are designed particularly for use in oxidizing atmospheres, i.e., those containing oxygen. Neutral atmospheres such as nitrogen and rare gases as well as CO and CO₂, can be harmful to MOLY-D elements. Maximum element surface temperatures in various gases are shown in the table above.

Reducing atmospheres attack the protective layer and therefore lower permissible maximum use temperature.

Air
Silicon and molybdenum can oxidize at approximately 550ºC (1020ºF). The reaction product is a yellow powder called “pest”. Such “pesting” is normally innocuous since it is merely a surface phenomenon.

Since both H₂O and CO₂ are oxidizing, their presence in a furnace atmosphere is beneficial, elevating maximum temperature.

Exogas
This atmosphere typically comprises 10% CO₂, 5% CO, 15% H₂ and the balance N₂. This atmosphere is considered oxidizing with respect to MOLY-D.
**Endogas**
This atmosphere typically comprises 20% CO, 40% H₂ and the balance N₂. The Maximum use temperature will be determined by dewpoint and gas velocity.

**Carburizing atmosphere**
MOLY-D elements are not attacked by the atmosphere in a Carburizing furnace. If carbon builds up in this type of furnace it should be removed by periodic firing in oxidizing conditions.

**Nitrogen atmosphere**
Nitrogen in a furnace atmosphere is typically used for nitration of ceramics, as a protective gas, or to balance the furnace atmosphere.

Nitration of ceramics is normally carried out at 1250-1550ºC. If the protective glaze coating on the element were degraded, nitrogen could react with the MoSi₂ on the element surface to form silicon nitride (Si₃N₄) which would scale off to damage the element. When operating below 1250ºC (2280ºF) element temperature the reaction is minor. However, above 1500ºC (2920ºF) up to 1700-1800ºC (3090-3270ºF) element performance is dependent on the dewpoint and time at temperature.

In cyclic conditions, the oxide layer on the elements can be restored by operating for a short time in air at 1500ºC. When operating for extended periods at temperature (continuous furnaces), the actual formation of a thin layer of Si₃N₄ at the surface of the elements offers the best protection against further gaseous reaction. The element’s protective glaze can be restored in the furnace where the elements are installed, by operating them in air above 1550ºC (2820ºF) for a couple of hours. I Squared R offers pre-glazed elements for use in Nitrogen atmospheres.

**Nitrogen and Hydrogen**
Any mixture of these gases should be treated similarly to hydrogen.

**Hydrogen**
The effect of hydrogen is significant. Dry hydrogen can reduce SiO₂ and MoSi₂ to form silicon and silicides with lower silicon content. Reaction rate varies directly with temperature and inversely with dew point.
**Floride and Chlorine**
MoSi$_2$ is attacked severely by halogens even at low temperatures. They can occur as pyrolysis products of charge contaminants.

**Vacuum**
MOLY-D elements are not intended for use in a high vacuum at high temperatures. The adjacent graph gives maximum element surface temperature as a function of furnace atmospheric pressure.

**Metals**
All metals react with MoSi$_2$ at high temperatures to form silicides. Since dust from metal will react with the element’s protective glaze it is recommended the Moly-D element be protected from metal splashes and fumes.

**Alkali**
Alkali metal oxides and salts act as a fluxing agent and react with the protective glaze on the elements. Since castable furnace linings contain alkalis, their selection for high temperature (1550-1600°C) furnaces is critical, and should not be used beyond this temperature.

**Ceramics**
If element supports are used, element temperature should not exceed 1600°C to prevent reaction with the support. Suitable support materials are mullite and sillimanite.

In firing of ceramics, decomposition products of organic materials - binders, plasticizers, ect.- must be removed to prevent element contamination at high temperatures.

**Glass**
Moly-D elements are generally well-suited to glass melting furnaces.