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MAXIMUM RECOMMENDED ELEMENT TEMPERATURES IN ATMOSPHERES				
Atmosphere	**MD-31**		**MD-33**	
	ºC	*ºF*	ºC	*ºF*
Air	1700	*3090*	1800	*3270*
Nitrogen	1600	*2910*	1700	*3090*
Argon, helium	1600	*2910*	1700	*3090*
Dry Hydrogen, dewpoint -80ºC (-112ºF)	1150	*2100*	1150	*2100*
Moist hydrogen, dewpoint 20ºC (68ºF)	1450	*2640*	1450	*2640*
Exogas (e.g. 10% CO_2, 5% CO,. 15% H_2	1600	*2910*	1700	*3090*
Endogas (e.g. 40% H_2, 20% CO)	1400	*2550*	1450	*2640*
Cracked and partially burnt ammonia (≈8%H_2)	1400	*2550*	1450	*2640*
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 CO_2, 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 H_2O and CO_2 are oxidizing, their presence in a furnace atmosphere is beneficial, elevating maximum temperature.

Exogas

This atmosphere typically comprises 10% CO_2, 5% CO, 15% H_2 and the balance N_2. This atmosphere is considered oxidizing with respect to MOLY-D.

Endogas

This atmosphere typically comprises 20% CO, 40% H_2 and the balance N_2. 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 $MoSi_2$ on the element surface to form silicon nitride ($Si_3 N_4$) 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.

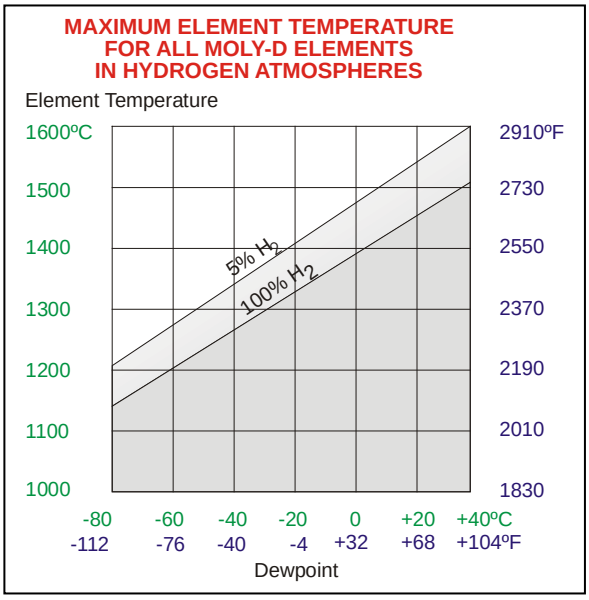
In cyclic conditions, the oxide layer on the elements can be restored by operating for a short time in air at 1500ºC. When operating for extended periods at temperature (continuous furnaces), the actual formation of a thin layer of $Si_3 N_4$ at the surface of the elements offers the best protection 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 SiO_2 and $MoSi_2$ to form silicon and silicides with lower silicon content. Reaction rate varies directly with temperature and inversely with dew point.



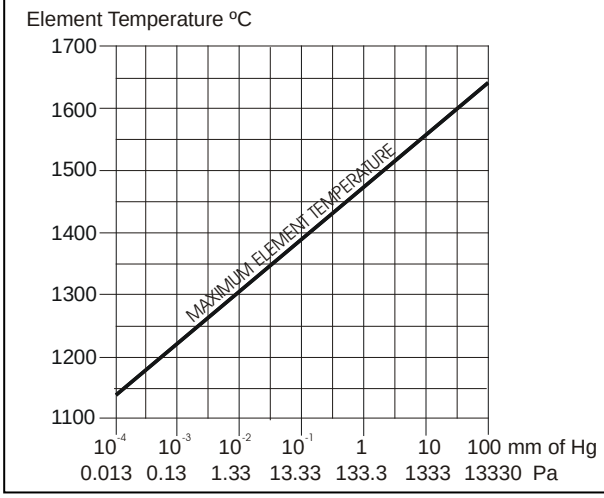
Floride and Chlorine

$MoSi_2$ 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.

MAXIMUM ELEMENT TEMPERATURES FOR CONTINUOUS OPERATIONS IN A VACUUM Moly-D GRADE MD-31 and MD-33



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 (1550-1600ºC) furnaces is critical, and should not be used beyond this temperature.

Ceramics

If element supports are used, element temperature should not exceed 1600ºC 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.