



# Metallurgical Processes

## Cracked Ammonia as a Forming Gas for hardening of metals

Application Notes



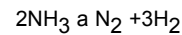
Steel Furnace

### Background

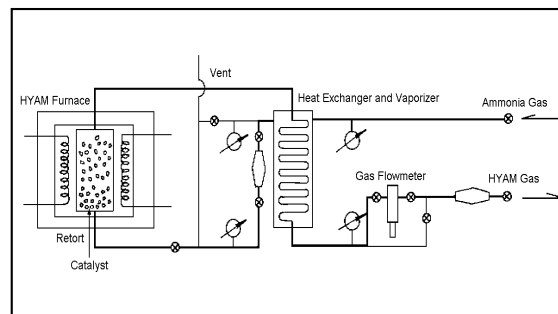
Hydrogen gas is widely used for the bright hardening of many kinds of metals. There are two main delivery methods for this process - bulk hydrogen from storage cylinders and cracked ammonia. Both delivery methods have advantages and disadvantages - cost and fire hazard in the case of pure hydrogen and corrosion risk and human safety being the main considerations in the case of cracked ammonia. However, generally nowadays cracked ammonia plant is the more common method of provision of a reducing/hardening atmosphere for steel and other metals furnaces.

### What is the process in an ammonia cracker?

Pressurised liquid ammonia is heated in order to vaporise it and is then passed over a nickel catalyst at a temperature of about 1000 oC, which causes it to dissociate into its component parts - hydrogen and nitrogen. The chemical equation for this reaction is:



The diagram below (courtesy of HYAM web site) illustrates the cracking process.



### Applications for dissociated ammonia

The forming gas is used in conveyer furnaces and in tube furnaces for annealing processes in a reducing atmosphere: brazing, sintering, de-oxidation, and nitridation.

Further applications for forming gas are:

Brazing	Metal annealing	Hydrogenation of organic compounds
Sintering	Stainless steel wire anneal	Galvanization
Deoxidization	Metal powder anneal	Production of Forming Gas
Nitridation	Bimetal products anneal	

### Gas Properties

The gas generated by the dissociation of ammonia is known as forming gas. It consists of 75 Vol% hydrogen and 25 Vol% nitrogen.

As a result of complete dissociation into hydrogen and nitrogen, very little undissociated ammonia remains and the dew point temperature of the resulting gas should be very low (well below -30°C).

As an option and in order to reduce the dew point of the generated forming gas further, a special forming gas purifier may be used. Using molecular sieve technology, the dew point of the generated gas can be reduced to less than -65°C. Two adsorber units are working in parallel, one for adsorbing moisture and uncracked ammonia from the forming gas and the other one is heated for regeneration. Periodically the gas flow is changed automatically in order to maintain a low output dew point.



The Dew Point Specialists

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Q6284 (UK)



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Description	Ammonia NH <sub>3</sub>	Hydrogen H <sub>2</sub>	Nitrogen N <sub>2</sub>
Molecular Weight	17,03	20,158	280,134
Boiling Point (BP) in °C	-33,35	-252,87	-195,8
Liquid Density at BP in kg/m <sup>3</sup>	682,1	70,0	804,0
Vapor Density at BP in kg/m <sup>3</sup>	0,8906	1,329	4,613
Density at RT in kg/m <sup>3</sup>	0,7710	0,0899	12,506
Heat of Vaporization in kJ/kg	1368,2	451,9	199,2
Solubility in cold water in g/100ml	89,9	-	-
C <sub>p</sub> in kJ/kg (1 atm, RT)	2,188	14,2	1,038

## Dew-point measurement in cracked ammonia

As long as the forming gas is free from trace ammonia, any Michell impedance type hygrometer may be used for either on-line or spot-check measurement. Michell's low-cost Easidew range (transmitter, on-line hygrometer and portable hygrometer) are suitable for measurements in locations with no hazardous area classification. This is common in many furnace applications. If a measurement location is declared as hazardous under an ATEX directive, Michell offers its premium hygrometer range, comprising Transmet IS dew-point Transmitter, Cermet II IS Hygrometer (giving local display and alarms) or the Cermax IS hygrometer - a portable intrinsically safe dew-pointmeter.

All the above instruments are fully factory calibrated with traceability to UK and International standards and offer high accuracy, long term reliability and ruggedness, backed up by a first class after sales service that includes the option for extended maintenance agreements and exchange sensor services.

**Note: a similar application is in the preparation process for tin galvanising of sheet steels where endothermic gas is often used to blanket the furnace to prevent surface oxidation. There is also a requirement to measure the dewpoint in a Nocolok furnace, used for controlled atmosphere brazing (CAB) in the production of heat exchangers.**

## Reference Users

British Steel, IMCI Italy, Orb Electrical Steels, UES Steel

