

## Process Safety and Dangerous Goods

# Thermal stability

Industrial processes comprise a wide variety of process steps, amongst which are storage, handling, separation and conversion. While during conversion an intentional instability is introduced, unintentional instability may occur during other process steps or during storage.

This stresses the necessity of knowing not only the safety features of a reactive system itself but also of the individual materials during handling, drying, storage, etc. Relevant features are, for instance, self-heating of materials, compatibility of a material with its packaging, gas production at elevated temperatures and the influence of contaminants.

TNO offers expertise in all aspects related to safety of dangerous goods.

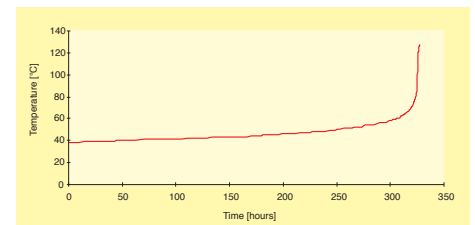
- Production
- Processing
- Storage
- Transport



### Effects

Thermal instability or incompatibility of materials may result in considerable gas production or temperature increase due to heat production. This may, for example, induce a fire or an explosion. Even when no dangerous effect occurs, the quality of the materials may decrease. To avoid such situations, it will be necessary to establish safe conditions for

unit operations (such as drying), storage and transport. These conditions not only depend on the characteristics of the material involved but also on the environment.



Typical result of an Adiabatic Storage Test.

### Characterisation of thermal instability

At TNO Defence, Security and Safety a wide variety of standard test methods and specially developed equipment are available. This ranges from fast screening techniques requiring only milligrams of sample to very accurate equipment in which amounts up to one kilogram can be investigated.

Examples of available equipment are:

- Differential Scanning Calorimetry;
- Differential Thermal Analysis/ Thermogravimetry;
- Thermomechanical Analysis;
- Adiabatic Storage Test and Isothermal Storage Test/Heat Flow Calorimeter;

- Thermal Activity Monitor;
- Vacuum Stability Test;
- Mini-autoclave (gram-scale DTA with pressure measurement);
- Advanced Reactive Systems Screening Tool (ARSST).

Several of these tests can be run, for instance, under different atmospheres (helium, oxygen, etc.), under high pressures or at different humidities.

#### Influence of environment

The question whether thermal instability induces a safety problem, loss of quality or any other relevant effect not only depends on the nature of the product(s) involved but also on the environment. Insulation, wind, sun radiation and composition of the packing material will all influence the thermal behaviour of the material. Moreover, the dimensions of the package or the storage facility play an important role.

Therefore, thermal stability must always be considered in relation to the environment and not only as a property of the sole material.

#### Computer modelling

As thermal behaviour depends both on the nature of the materials and on the way materials are stored, the behaviour in practical situations can be simulated using computer codes. The codes allow the calculation of, for instance, the induction time of a runaway reaction (or the critical temperature) of a particular storage like a silo or a stack of packages in a certain environment (a container, a ship, etc.).

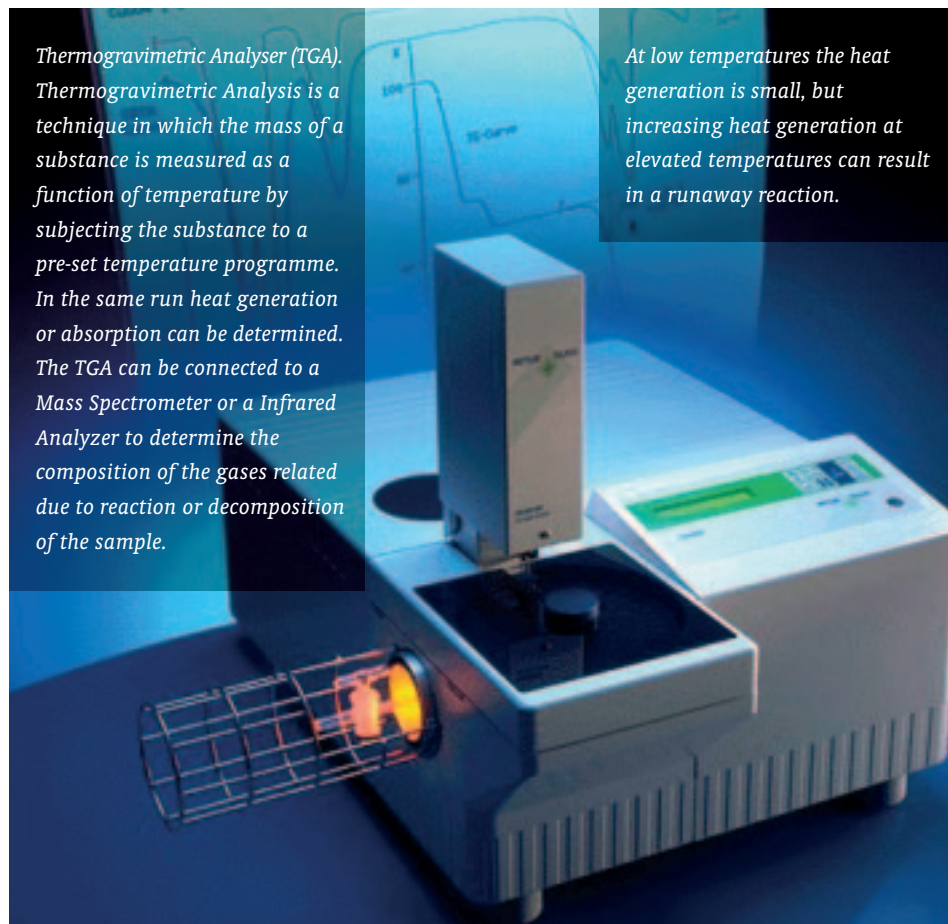
#### TNO Defence, Security and Safety

'TNO Defence, Security and Safety' is the title under which TNO operates as a strategic partner for the Dutch Ministry of Defence and makes innovative contributions to enhancing the security of the Netherlands both at home and abroad. We also use our accumulated knowledge for foreign governments and for defence-related industries.

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*Thermogravimetric Analyser (TGA). Thermogravimetric Analysis is a technique in which the mass of a substance is measured as a function of temperature by subjecting the substance to a pre-set temperature programme. In the same run heat generation or absorption can be determined. The TGA can be connected to a Mass Spectrometer or an Infrared Analyzer to determine the composition of the gases related due to reaction or decomposition of the sample.*

*At low temperatures the heat generation is small, but increasing heat generation at elevated temperatures can result in a runaway reaction.*

#### Process Safety and Dangerous Goods

Within the field of safety of dangerous goods and industrial processes, we offer services on:

- Process safety;
- Product safety;
- Explosion safety and control;
- Product and process optimisation.

Whenever possible, we endeavour to give added value to your investment in safety by combining safety with (economic) optimisation of design, maintenance, control and production. A team of specialists is available to apply the expertise for finding a solution to your problem. Please visit our website at: [www.tno.nl/prosafe](http://www.tno.nl/prosafe)