TAR GUIDELINE

A STANDARD METHOD FOR SAMPLING AND ANALYSIS OF TARS AND PARTICLES IN BIOMASS PRODUCER GASES

J.P.A. Neeft (ECN / Novem), S.V.B. van Paasen (ECN),
H.A.M. Knoef and G.J. Buffinga (BTG), U. Zielke (DTI),
K. Sjöström and C. Brage (KTH), P. Hasler (Verenum),
P.A. Simell and M. Suomalainen (VTT),
M.A. Dorrington and L. Thomas (EMC)

Sponsored by

European Union

Novem

ECN
Contents

• Aim of this presentation
• Introduction
• Outline of the Guideline
• Definition of tar
• Use in practice and standardisation
• Conclusions and acknowledgement
• Discussion
Aim of this presentation

1. Present project “Tar Protocol”

2. Start discussion on questions
   - "do we have to define the word “tar” ?"
   - "do we need a Protocol, Guideline or Standard ?"

   Discussions will continue tonight in Expert Meeting (19.00 – 22.00, same room)

   Results will be presented in Session O2J (Friday morning, 10.00 – 11.00)
Introduction –
Project “Tar Protocol”

Project was executed by 17 partners from Europe and North-America:
Introduction –
Project “Tar Protocol”

Aim of the project is to:

(1) Develop a Guideline:
- Describing necessary equipment and procedures for sampling-, post-sampling- and analysis of tars
- Suitable for measurement of tars at all relevant conditions (0 – 900°C; 0.9 – 60 bars) and concentrations (1 mg/m$^3$ – 100 g/m$^3$)
- Simultaneous measurement of particles and soot

(2) Disseminate the Guideline to become a world-wide accepted standard measurement method
Introduction –
Project “Tar Protocol”

We renamed the Protocol into “Guideline” as:

**Protocol** = Outcome of two Working Groups (1998)

**Guideline** = Method to be recommended and basis for comparison, nothing more and nothing less

*(see later)*

**Standard** = Method to be approved by certification institute (e.g. CEN).
Outline of the Guideline

The Guideline is a modular method:

- Volume flow meter
- Pump
- Backup adsorber
- Gas washing bottles
- Water bath (T = 20 °C)
- Salt and ice bath (T = -20 °C)
Outline of the Guideline

Figure of sampling train
Outline of the Guideline

Sampled tars on impinger bottles
Outline of Guideline —
R&D Results

Main R&D results are:

- Aerosol formation is a major problem in tar sampling
  Result is incomplete tar collection
  => a liquid solvent is needed

- Selection of liquids gave 4 candidates
  DCM, ethanol and 1-methoxypropanol have disadvantages
  => isopropanol is an appropriate and the selected solvent

- Even with a solvent, quantitative collection is not obvious
  => sampling train must be carefully designed
  Imp. Train temp.: 4x +20°C  2x -20°C + a quartz filter or frits

CONCLUSION: A Guideline ensures good
sampling and analysis procedures over a wide
range of conditions
Outline of Guideline

- R&D Results

Tars are found in sixth impinger bottle as well as after the impinger train.

Y-axis: Sum of tar compounds measured by GC up to pyrene.
Tar collection in 1-Methoxy-2-propanol at 0°C (1-4) and -70°C (5-6).
Analysis of tars => two possible numbers:

- Gravimetric (evaporation / condensation)
- Compounds analysis
Definition of tar

Definition is controversial: “what are tars”?

We believe and propose that the word “tar”
- irrespective of the definition given, will always cause discussion and confusion as it is used in several fields and applications never having exactly the same meaning
- For example: even defined as “compounds that condense” is ambiguous as condensation or contamination varies with T, p, [tar], [H₂O]

If a definition causes confusion and is ambiguous, then:

DO NOT DEFINE!
Definition of tar

How to measure “tars” when we accept that “tar” it is an ambiguous term without well-defined meaning?

We can measure “tars” once we define what we measure!

How to compare “tars”?

- Measure with the same method
  (=> same definition);

- Measure with different methods using the same definition
  (=> other methods. First: compare if two methods give same result at conditions considered)
Definition of tar

Example:

Comparison of Guideline with SPA method:

Conclusion: methods give same results in range phenol – pyrene. SPA can be used in that range.
Definition of tar

In the Guideline we measure two concentrations:

- **Concentration of gravimetric tar** = evaporation residue at standard conditions \((T, p, \text{ and } t)\)

- **Concentration of individual tar compounds** = those to be expected in biomass producer gases are listed (updraft, downdraft and fluidised bed gasification)

**Individual tar compounds**: SPA can also be used (range phenol – pyrene, downdraft and fluidised bed gasifier tar compounds)
Definition of tar

In conclusion:

• Do NOT define the ambiguous word “tar”

• Measure with own definition
  Report what you have measured

• For comparison of tar concentrations, use one basis for comparison (the Guideline):
  (a) measure numbers according to Guideline definitions
      (gravimetric tar and/or single compounds); or:
  (b) use the Guideline
Use in practice,
Standardisation

Implications for use

• The above does NOT implicate:
  – Use of the Guideline is mandatory or necessary
  – We all should compare

• The above DOES implicate:
  – If you want to compare your results with others, use a method that has been compared to other methods

• Practical implications that we foresee:
  – small gasifier systems: method that has been compared with Guideline. Result is gravimetric tar
  – larger gasifier systems: idem or Guideline. Compounds and/or gravimetric tar
  – commissioning of plants: idem, use one method! Guideline is preferred.
Use in practice, **Standardisation**

Standardisation needs:

- data on accuracy and reproducibility
- approval of national standardisation institutes

Standardisation = guarantee for quality

=> We believe standardisation is useful

A 2\textsuperscript{nd} EU project has been applied for
Aim of project is to standardise the Guideline into a CEN standard
(CEN = Commission Europeène de Normalisation)
Conclusions are:

- Guideline has been prepared
- Sampling conditions are essential due to aerosol formation
- Definition of tar is controversial. We propose:
  - Do not define the general word “Tar”
  - Define what you measure and make sure everyone measures the same = (1) Guideline gravimetric tar and (2) GC based compound analysis
- Use the Guideline when appropriate
  Else use method that was compared to Guideline
Conclusion and Acknowledgement

The following organisations are acknowledged for financial support:

- European Commission
- Netherlands agency for energy and the environment (NOVEM)
- Swiss Federal Office of Education and Science
- US Department of Energy
- National Resources Canada