

Improving Member States preparedness to face an HNS pollution of the Marine System (HNS-MS)

HNS-MS stakeholders meeting

Session 5 : Modelling HNS behaviour in the marine environment The near-field model CHEMSPELL

DG-ECHO civil protection funding mechanism 2014 Call for Prevention and Preparedness







In some specific cases, HNS can be **released from the water column** with different configurations:

- Leak from a sunken vessel, from a broken pipeline/well
- Pollutant with various behaviours (floaters, dissolvers, etc.)

Goals:

- Cover these specific underwater release scenarios
- Model the different physical/chemical involved processes
- Validate with experimental data and/or use results
- Provide relevant information of the water column



- CHEMSPELL : <u>CHEM</u>ical <u>Subsea</u> <u>P</u>lume mod<u>EL</u> for <u>L</u>eakage
- Simulation of **HNS behaviours and fate** in the water column, from the breach to the surface
- Integration in the decision support system prototype as near-field model to provide a source term to the HNS-MS far-field model
- 4 Scenarios includes the near-field model:
 - Spill from a sunk vessel (discharge estimated / breach characteristics known)
 - Spill from a broken pipeline (discharge estimated / breach characteristics known)

- Simulation for both **gas** and **liquid** entities
- It covers products with behaviours G, D, E, F, S (and combinations) in the water column



HNS types by Standard European Behaviour Classification

- Scenario **key parameters** for CHEMSPELL:
 - Type of scenario
 - Simulation time
 - Location, depth
 - HNS description (SEBC, physical-chemical constants)
 - Environmental conditions for the water column
 - Temperature, salinity, currents
 - Options













- Sunken vessel initialization
 - Model implemented from the work done by L. Aprin (EMA)
 - 4 configurations are considered : simple or double breach, for floating or sinking pollutant



- Evaluation of the flow rate at the breach based on Bernouilli's principle
- Evaluation of the draining time

- Plume Dynamic stage (PDS)
 - For the jet/buoyant plume stage
 - A Lagrangian integral model based on a **control volume**
 - Shear and forced entrainment of ambient water are evaluated
 - Conservation of mass, and state variables
 - Conservation of momentum



- Advection Diffusion stage (ADS)
 - When buoyant plume reaches a neutral buoyancy level
 - HNS cloud from the CV is divided into numerous parcels
 - Droplets are **advected** by ambient current
 - Droplets are **diffused** by ambient turbulence (use of a random walk)
 - HNS dissolved volume is also represented by parcels



Session 5 : Modelling HNS behaviour in the marine environment The near-field model CHEMSPELL

- Slip velocity
 - Crucial to know the time spent in the water column
 - Impact on **dissolution**
 - Impact on surfacing time
 - Use of the Clift correlations for 3 regimes: Spherical, ellipsoidal and spherical-cap
 - Experimental data shows good agreements



Experiments comparisons of methyl ter butyl ether (on the left) and methyl methacrylate (in the middle) with Clift model (L. Aprin 2016). Comparisons of air bubble in tap water on the right. Co-funded by the European Commission, DG-ECHO HNS-MS stakeholders meeting Brussels – Belgium > 14/12/2106



Session 5 : Modelling HNS behaviour in the marine environment The near-field model CHEMSPELL

- Droplet size distribution (DSD)
 - At initialization, a DSD is evaluated based on experimental data and depends on flow rate:



Drop size distributions. On the left , flow rate < 10^{-4} m³.s⁻¹, on the right < 10^{-4} m³.s⁻¹. (L. Aprin 2016)

- Evolution with droplet dissolution
- During the PDS, the whole DSD is represented in each control volumes
- At the beginning of the ADS, each parcel corresponds to **one** class of the DSD

Session 5 : Modelling HNS behaviour in the marine environment The near-field model CHEMSPELL

- Dissolution
 - Common module between CHEMSPELL and HNS-MS
 - Dissolution rate is calculated at bubble/droplet/spillet scale as :

$$\frac{dn}{dt} = KA(C_s - C_0)$$

K the mass transfer coefficient $(m.s^{-1})$, A the contact area (m^2) , C_s the concentration at saturation (i.e. solubility $mol.m^{-3}$), C_o the ambient concentration $(mol.m^{-3})$

- Use of the HNS solubility value from data base
- Evaluation of the mass transfer coefficient K based on Sherwood Number formulations
- Next step : Validation with CEDRE/EMA experiments

Session 5 : Modelling HNS behaviour in the marine environment The near-field model CHEMSPELL

- Output data
 - Generation of netCDF file that contains : Concentration, velocity, droplet size distribution per depth, number of parcel, ..
 - A dedicated post treatment in the case of gas release





Co-funded by the European Commission, DG-ECHO

HNS-MS stakeholders meeting | Brussels – Belgium > 14/12/2106

Session 5 : Modelling HNS behaviour in the marine environment The near-field model CHEMSPELL

• HNS-MS / CHEMSPELL models interface



- CHEMSPELL technical description:
 - Programming languages : C++, Qt Framework
 - 64 bits executable binaries
 - OS: Debian 8 64 bits, Windows 7 64 bits







Thank you for your attention

Any questions ?



Co-funded by the European Commission, DG-ECHO

HNS-MS stakeholders meeting Brussels – Belgium > 14/12/2106