GENERAL DYNAMICS
Ordnance and Tactical Systems–Canada

Modified Version of the Variable Confinement Cook-Off Test (VCCT)

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Outline

- Introduction
- Variable Confinement Cook-Off Test background
- Modified VCCT test set-up
- Test and results
- Conclusions

Introduction

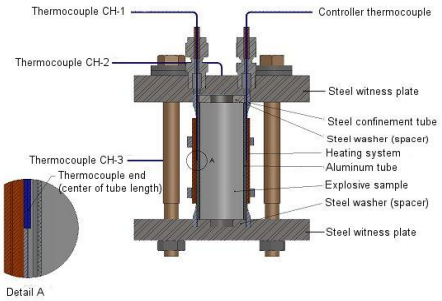
- **Cook-off is a major stimuli for insensitive munitions testing**
  - **Threat hazard analyses: Present in all the parts of munitions life cycle.**
- **Difficult to obtain actual data of temperature inside the tested object (Mainly for fast cook-off)**
- **Testing is expensive**
  - **Cost of fuel for fast cook-off**
  - **Long test for slow cook cook-off (even intermediate)**
- **Use of small scale tests**
  - **Understanding purposes**
  - **Primary selection of explosive formulations**

Variable Confinement Cook-off Test (VCCT)

- **Described in STANAG 4491**
- **Features**
  - **Small sample (useful when small test capabilities available)**
  - **Simple design**
  - **Possibilities to study different heating rates covering slow to fast range**
  - **Different confinement steel sleeve (Importance to be studied)**
    - **From T15 (0.015”) to T120 (0.120”)**
- **Selected for IRAD and cost shared project**
  - **QFD with three tests methods (VCCT, STEX, TNO Tube test)**

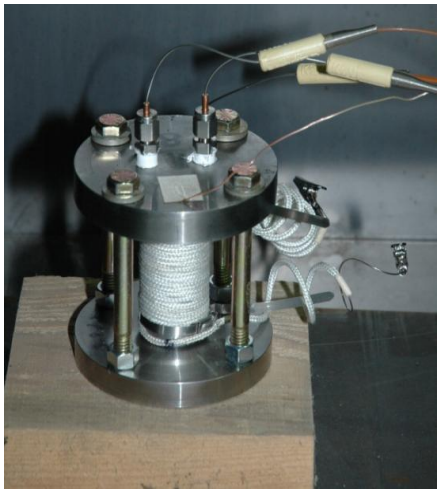
Variable Confinement Cook-off Test (VCCT)

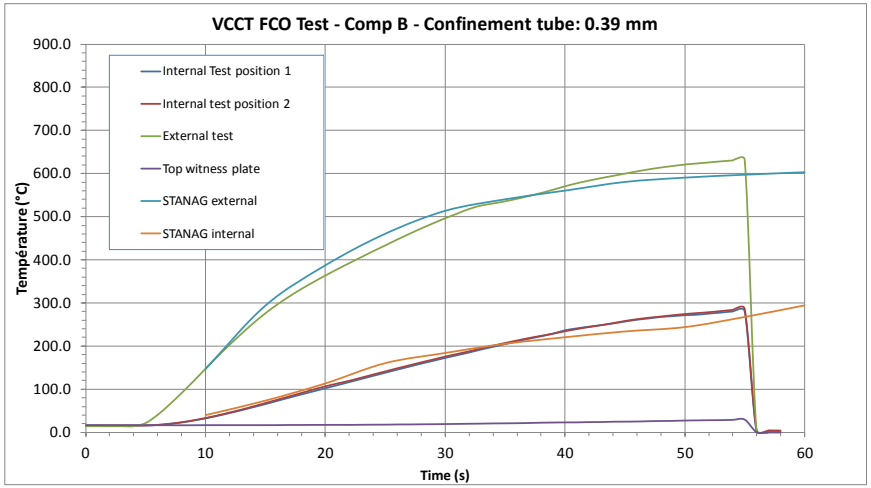
- **Background work performed**
  - **Installation of the set-up at GD-OTS Canada**
    - **Help and discussions from DRDC Valcartier (leaking)**
  - **Heating element study**
    - **SCO and ICO: Silicone band with embedded heating element to replace Mica barrel heating elements**
    - **FCO: Nickel-chrome wire insulated with Nextel ceramic braid**
      - **0.812mm (20 AWG) used instead of 1.14mm (17 AWG)**
      - **Adjust length with the confinement thickness to obtain the required heating curve**
      - **Wire set-up arrangement to make it sturdier**



Variable Confinement Cook-off Test (VCCT)

- **Background work performed (cont.)**
  - **Heating element study**
    - **FCO**
      - **Reproduction of the heating curve in the STANAG**

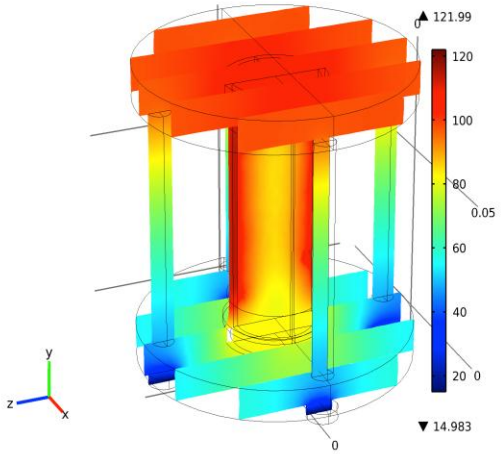




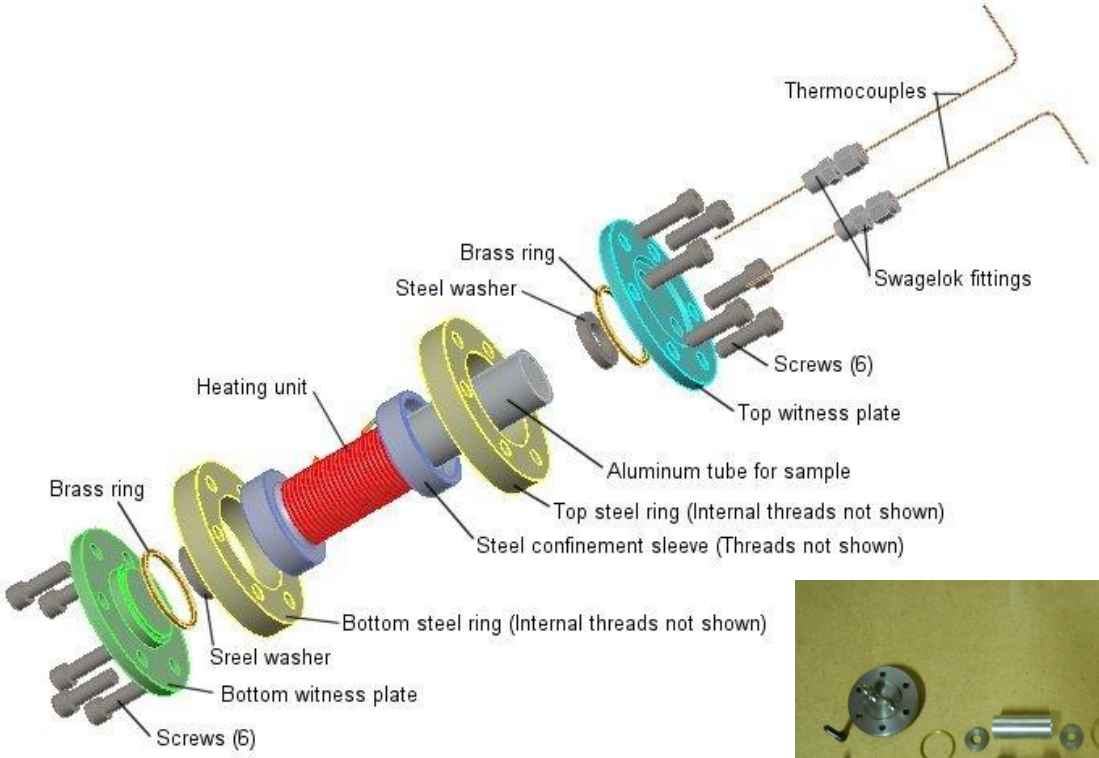
  - **Confinement study**
    - Steel material to produce the sleeves
    - Bursting pressure

Variable Confinement Cook-off Test (VCCT)

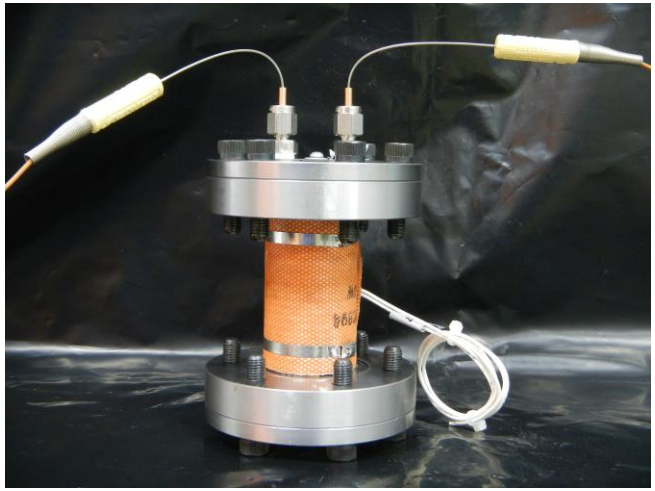
- **Features to be improved**
  - **Leakage between top witness plate and confinement sleeve.**
  - **Sleeve coverage by the heating band**
  - **Heat transfer aspects between plates and bolts acting as heat sink**

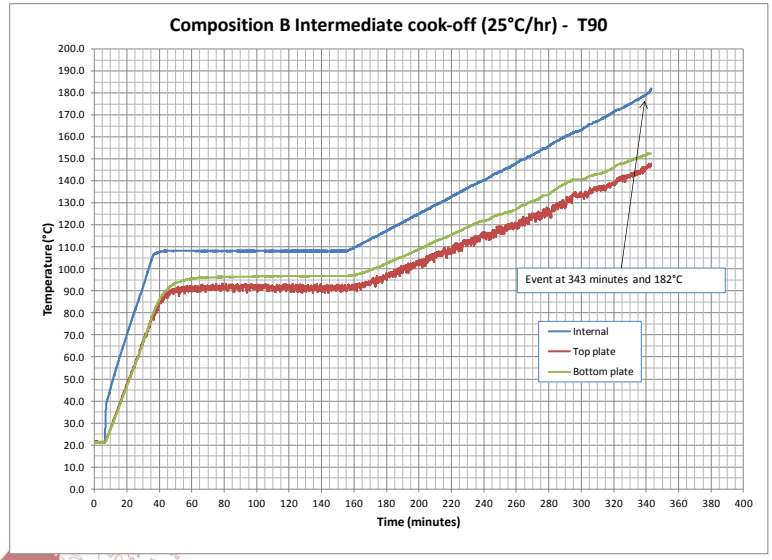


Modified VCCT test set-up

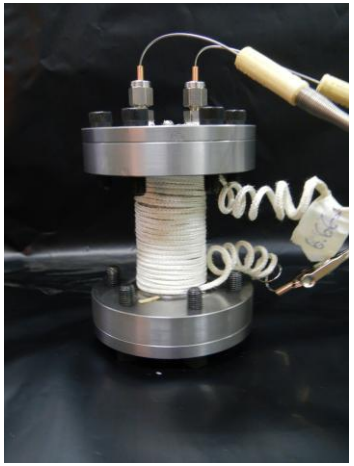


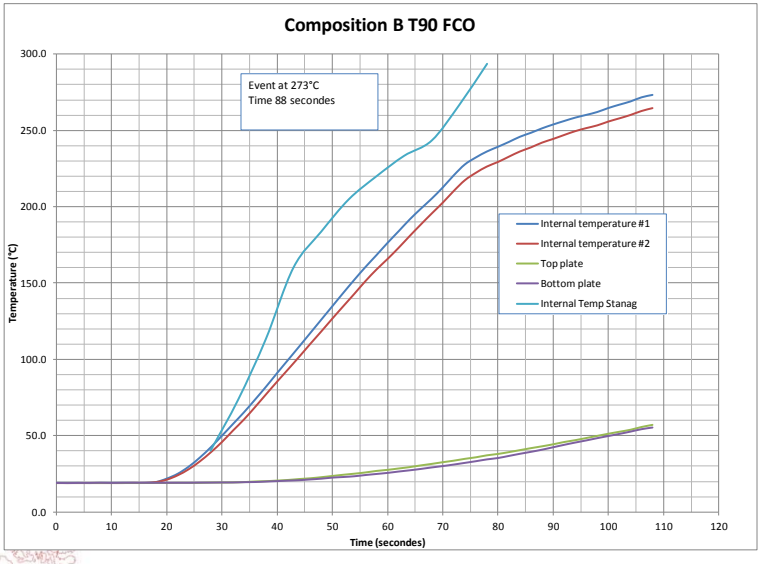
Testing with modified design





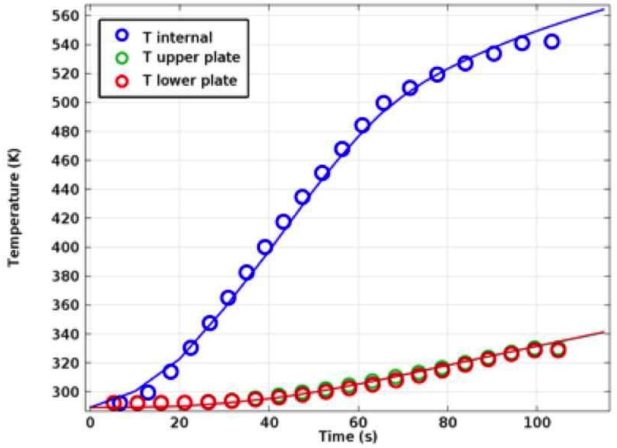
Testing with modified design

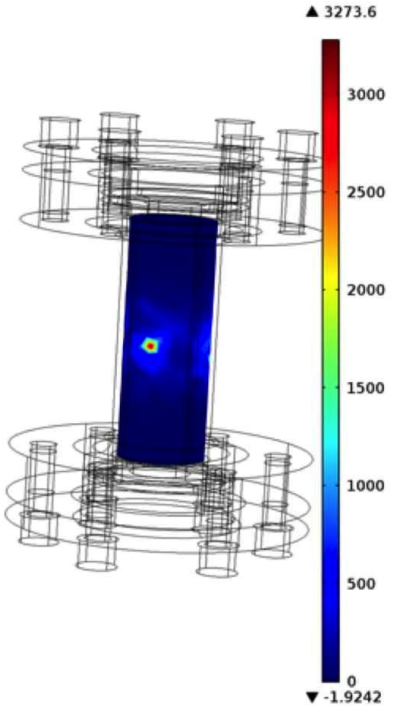




Simulation of new design

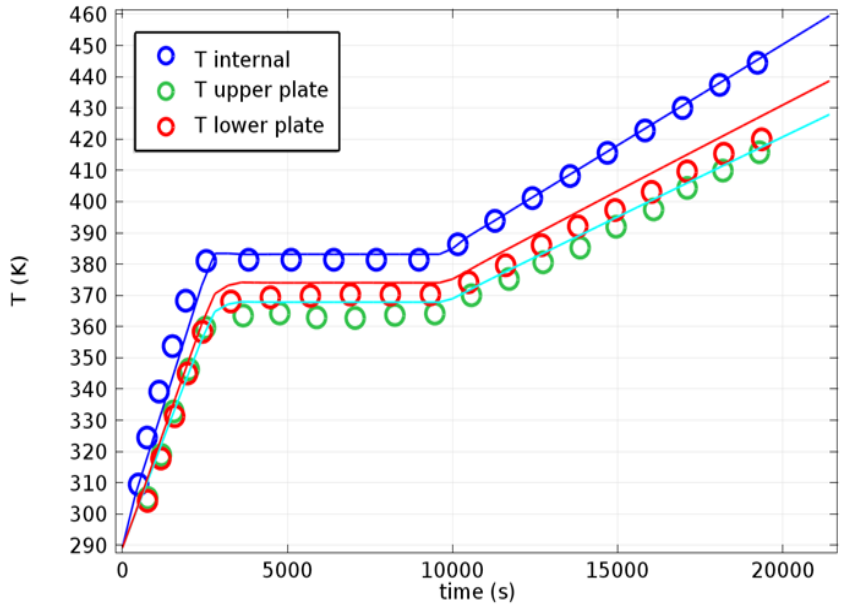
- Multiphysics simulation: Composition B fast cook-off confinement T45
  - Situation after 115 seconds (Calculated onset) – overestimation by about 15%
  - Circles = experimental data – Lines = computed data
  - Decomposition products concentration surface plot

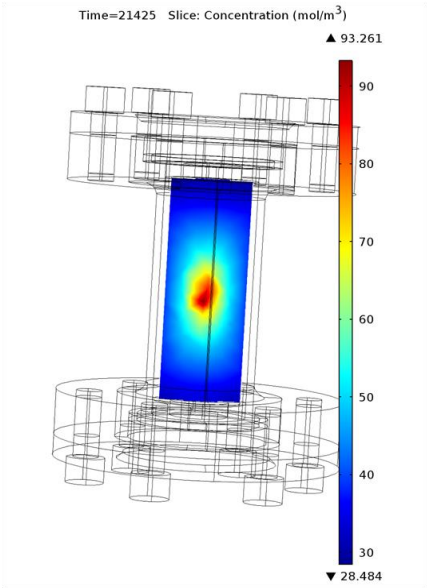




Simulation of new design

- Multiphysics simulation Composition B Intermediate cook-off (25°C/hr) after soaking at 108°C - Confinement T45
  - Situation after 21425 seconds (Onset time) – Overestimation by about 15%
  - Decomposition product concentration surface plot





Conclusions

- The results from the different programs involving the selection and performance of a small scale cook-off test at GD-OTS Canada led to the following conclusions.
  - The Variable Confinement Cook-off Test (VCCT) set-up as described in STANAG 4491 was built and tested successfully with different type of explosives at different heating rate (slow, intermediate and fast).
  - Some weaknesses have been observed with the set-up (leaks, temperature control and reproducibility) but review of other types of tests indicated that it was still the one presenting the best potential for GD-OTS Canada because of its small size and versatility mainly which led to its selection for further work.
  - Modifications were applied to achieve reproducibility of heating and controlling the heat transfer to environment as well as leakage. It is considered that the modified design while improving the test conditions can still provide results comparable with previous VCCT testing. The results achieved met the expectations.
  - Computer simulation with a multiphysics code provided good reproducibility of the experimental results and was instrumental to the improvement of the test set-up.

Future work

- Obtain more data with different explosives to be in a position to define more precisely the reaction level with the new design
- Carry on simulations work with COMSOL multi-physics computer program to study both heat transfer and stress development in the system to confirm the actual effect.
- Carry on more studies with different steel confinement sleeves to finalize the selection of the thicknesses to develop future explosive formulations evaluation plan.
- Work on the improvement of the fast heating test method for the thicker confinement sleeve such as the T90 to obtain the temperature curve shown in STANAG 4491.
- Study methods to add more thermocouples to the test as well ways to include pressure transducer to obtain quantitative data on the reaction level.

Acknowledgements

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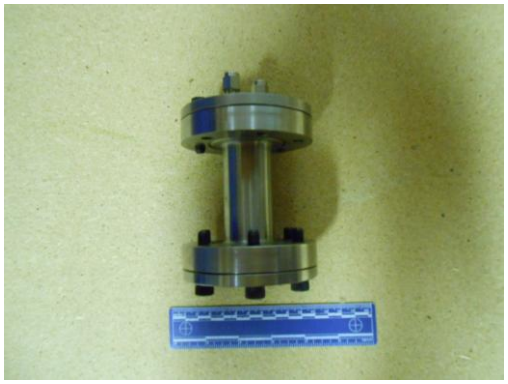
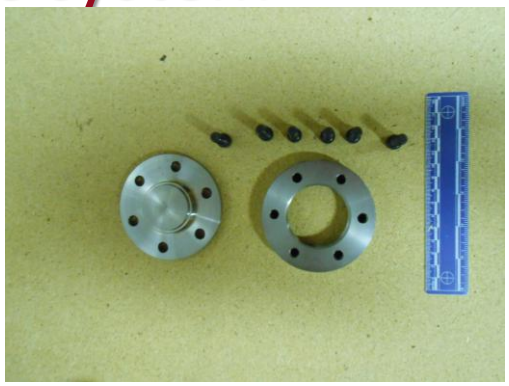
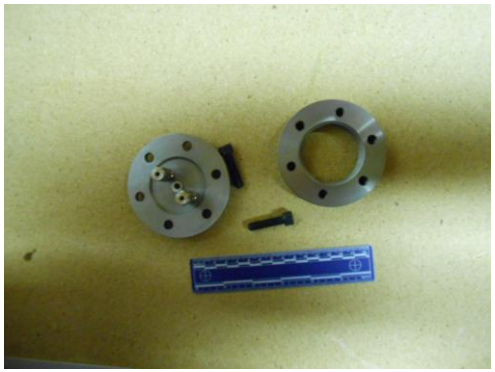
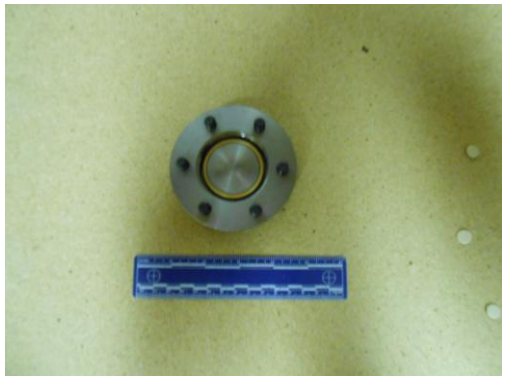
- ☆ John Makkus (TNO, Netherlands)

Additional pictures of the system





Additional pictures of the system