Transport Canada – Research update – October 2021

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Project Title	Abstract	Sponsor	Contractor	Target end date	Status
Performance of TC-117 Tank Cars under Derailment Conditions	Develop and use train derailment simulation software to assess the differences in puncture resistance of TC-117J and TC-117R tank cars in derailment conditions.	TC (in collab. with FRA)	Sharma & Associates	Initial modelling March 2022	Modeling will combine previous tank car shell and top fittings investigations in the same derailment simulations of up to 100 tank cars in length. Both 117J and 117R (from a variety of source tank cars) tanks cars will be assessed in term of puncture resistance and top fittings protection.
Behavior of crude oil and other complex mixtures in tank cars exposed to fire conditions (analysis of experimental data)	Further analysis of the 2-m heptane, Bakken, and dilbit pool fires to review calculations, further analyse the burning behaviour of the tested fuels, and compare fire behaviour between the tests and similar prior experiments.	TC	National Research Council of Canada (NRC)	Completed June 2021 Publication Fall 2021	Analysis has been completed, updates made to the time period for averaging of data, particularly for dilbit which does not burn in a steady manner. Differences in the fire behavior of the crude oils are identified. Publication planned shortly.
Crude oil pool fire numerical modelling	A numerical model of crude oil pool fires was developed as a proof of concept, to determine if $1/10^{th}$ scale crude oil pool fire experimental tests to be scaled up to a full scale incident.	TC	National Research Council of Canada (NRC)	Final report completed September 2021 Publication Fall 2021	The numerical model was validated by simulating the 2-m heptane, Bakken, and dilbit crude oil pool fire tests that were conducted at Sandia National Labs. Report on the proof of concept has been finalized and publication is planned shortly.
Crude Oil Equation of State Modeling in Aspen HYSYS	A combination of experimental work and computational modelling to determine how crude oil behaves when heated in a closed container (such as a tank car). A model has been developed to predict crude oil behaviour in fire conditions and how it changes due to venting, chemical reactions, and heating rates.	TC	Natural Resources Canada (NRCan)	Final report completed August 2021 Publication Fall 2021	An Aspen HYSYS Tank Car Model was developed to simulate various types of crude oil as a tank car lading when engulfed in fire, and uses detailed heat flux information from the CFD model (below) to study the effects of variables (e.g. crude oil type and volatility, PRV performance and thermal protection) during accident scenarios. Final report is complete and publication is planned shortly.
2D Computational Fluid Dynamics Modeling of Behaviour of Crude Oil Inside Tank Cars	Investigate using computation fluid dynamics to model fluid motion and heat transfer in tank cars carrying crude oil or other flammable liquids in fires.	TC	Natural Resources Canada (NRCan)	Completed August 2021 Publication Fall 2021	A 2D CFD model was used with the Aspen HYSYS model to assess the behaviour of crude oil ladings under high temperature and pressure conditions (i.e. in fires). The heat transfer of crude oil in bare tank and thermally-protected tanks was studied using CFD. The CFD model was re-run with radiative heat flux boundary condition and results will be included in final report with EOS modeling (above).
Tank Car Steels & Finite Element Analysis Model	Development of a material model (based on previous tank car steel research) in a finite element analysis (FEA) code of a TC/DOT-117 tank car. FEA model will be used to simulate high temperature tank car failure.	TC	Natural Resources Canada (NRCan)	Completed September 2021 Publication Winter 2022	In 2018/19, a material model and DOT/TC117 tank car geometry model was created and initial fire scenarios were run in finite element analysis (FEA). A spreadsheet-based engineering model was also developed. Work in 2020-21 included refining the engineering model and running scenarios to compare between the FEA, engineering model and

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					AFFTAC. Inputs for fire exposure scenarios came from the CFD and HYSYS models for crude oil in a tank car. A variety of scenarios were run to determine outcomes to pool fire exposure for all three models. Final report is complete and publication is planned for Winter 2022.
Tank Car Weld Performance Project	Interested in understanding the high and low temperature performance of tank car steel (TC128B) weld performance.	TC	Natural Resources Canada (NRCan)	Completed April 2021 Publication Fall 2021	High and low temperature (-34°C/-30°F) testing of one TC128B circumferential weld sample from non-pressure tank car was completed. Report has been finalized and publication planned for Fall 2021.
Modelling of a cryogenic UN portable tank during fire testing	Develop a model of an UN portable tank containing a cryogenic liquid, exposed to fire. The tank geometry will be incorporated into numerical simulation software capable of modelling chemical reactions, thermal loading and two phase equation of state. Model will be validated using data from the FRA's full scale UN portable tank fires.	TC (in collab. with FRA)	Friedman Research Corporation (FRC)	Phase 1: March 2018 Phase 2: February 2022	Phase 1of the project included data analysis from the FRA's UN portable tank fire LN2 test, and proof of concept of a model to reproduce the tank, flat car and lading during the fire test conditions. Phase 2 is underway and includes model refinement to incorporate liquefied natural gas, simulating the effects of PRD exhaust and using the refined model to predict effects of various prolonged fire accident conditions and rollover conditions. Remaining validation tasks can be finalized after second fire test (scheduled November 2021).
Validation of Dangerous Goods Car Location in Train Literature Review	An assessment of the effectiveness of the dangerous goods cars placement rules outlined in section 10.6 of the TDG Regulations (TDGR).	TC	National Research Council of Canada (NRC)	Completed March 2021 Publishing Fall 2021	Report on Phase 2 tasks (analysis of literature on buffer cars and dangerous goods car placement, and detailed accident analysis comparing different buffer car rules) is complete. Final report will be published Fall 2021. Some findings will be used in the modelling of in-train forces project (below).
Modeling of in-train forces in DG trains	Computer simulations of DG-carrying train configurations (DG cars and buffer cars), track configurations, and operating scenarios to determine their effect on in-train forces and derailment risk of DG-carrying trains.	TC	National Research Council of Canada (NRC)	Phase 1: March 2021 Phase 2: March 2022	Phase 1 included developing simulation scenario plan, writing software to automate pre- and post-analysis, and performing preliminary simulations to inform remaining undefined scenarios. Phase 2 work will model the planned scenarios and assess effects of varying train configurations, track configurations, and operating scenarios. Variables of interest have been prioritized and initial cases are being run.
Hard Coupling Study	Investigation into whether current hard coupling regulations are effective at preventing damage from coupling events and identifying damage if it does occur.	TC	Natural Resources Canada (NRCan)	Completed April 2021 Publishing Winter 2022	FEA modelling was completed to simulate dynamic impact simulations of hard coupling, focusing on the stub sill-tank car junction at 25 and -40°C. Material properties of common stub sill materials (A572) were also reviewed. Final report is complete, publication planned this Winter.
Assessment of advanced non-destructive testing of tank cars and highway tanks	Assessment of applicability of two methods for tank car inspections: Current Field Measurement (ACFM) & Infrared Thermography, followed by technology feasibility study of ACFM.	TC	National Research Council Canada (NRC)	Completed April 2021 Publishing Winter 2022	Phase 2 of this work was a technology feasibility study where sample plates with known defects, cracks and flaws underwent an ACFM inspection and compared to standard surface inspection methods, Magnetic Particle & Liquid Penetrant, by certified NDT

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					Inspectors. A sample library of test plate specimens was loaned for this study by FRA, and ACFM inspections of the test plates were completed. Final report is complete, publication planned this Winter.
Research Related to the Transport of Petroleum Crude Oil	TC is participating at the Canadian Crude Quality Technical Association (CCQTA)'s committee to develop an H_2S field tester project. The goal is to develop and validate a field tester to measure H_2S gas concentration that evolves into the vapour space of a petroleum crude oil container under equilibrium conditions.	CCQTA members	Omnicon Consultants	Pending contractor review	Latest prototype of analyzer produces consistent results, but work needs to be done to reduce unit size and validate the accuracy of the vapour measurements. Contractor is reviewing required funding, next steps, and schedule to meet these objectives. An ASTM method would be drafted concurrently with the final design build.
Comprehensive review of the criteria and thresholds for emergency response assistance plans (ERAPs) in the *Transportation of Dangerous Goods* (*TDG) Regulations*	The objective of this project is to develop a hazard- and risk-based assessment tool/methodology for systematically establishing ERAP requirements for the various classes of dangerous goods. This tool will be used to conduct a review of criteria and thresholds for ERAPs currently in the *TDG Regulations*, to better reflect today's TDG landscape.	TC	Triox Environmental Emergencies Inc.	Fall 2023	The work kicked off in June 2021.