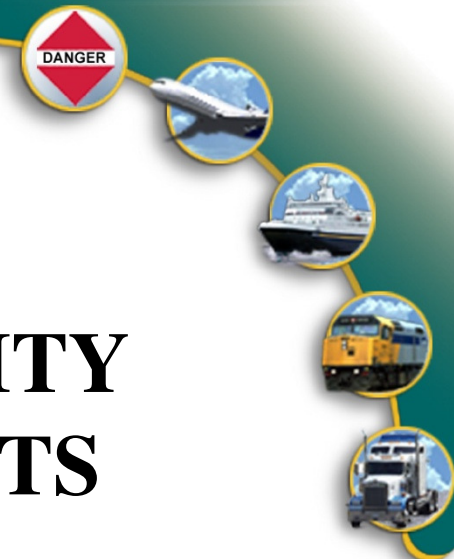




Transport
Canada

Transports
Canada



TANK CAR SAFETY & SECURITY SIGNIFICANT IMPROVEMENTS CAN/USA 1970s-2006

MARTS TECHNICAL CONFERENCE
MONTREAL 17-20 OCTOBER 2010

JEAN-PIERRE GAGNON

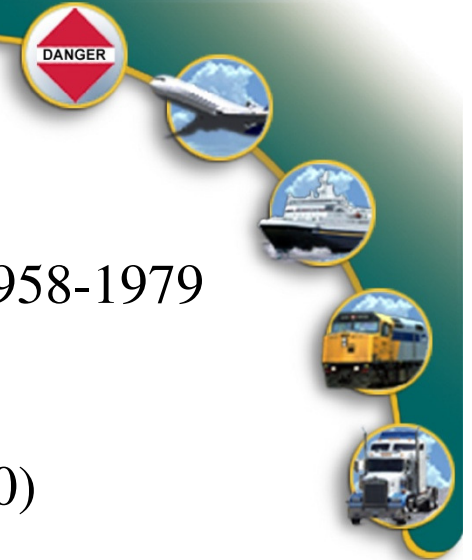
SUPERINTENDENT, RAIL TANK CARS

TDG REGULATORY AFFAIRS, OTTAWA, CANADA



Canada 

SCOPE



- OVERSIGHT BODIES
- ACCIDENT & SAFETY ISSUES DRIVING CHANGES 1958-1979
- OLD TANK CAR CHARACTERISTICS/STYLES
- RESEARCH & OTHER SAFETY INITIATIVES (PRE 1980)
- NEW SAFETY SYSTEMS DEVELOPED BY MID 1980s
- PRESCRIBED SAFETY IMPROVEMENTS UNTIL MID 1980s
- EXPERIENCE GAINED FROM 1985-2006
- ACCIDENTS/SPECIFIC PROBLEMS & LESSONS LEARNED/
 SUBSEQUENT REGULATIONS & REQUIREMENTS/RESEARCH
- MORE RECENT LPG, NH₃ & CL₂ TANK CARS
- SECURITY
- SUMMARY/CONCLUSIONS



OVERSIGHT BODIES

FEDERAL REGULATORY:

US: DOT/FRA

-ISSUES & ENFORCES CFR 49, DOT TANK CAR SPECIFICATIONS;
MAINTENANCE & USE

CANADA: TRANSPORT CANADA/TDG

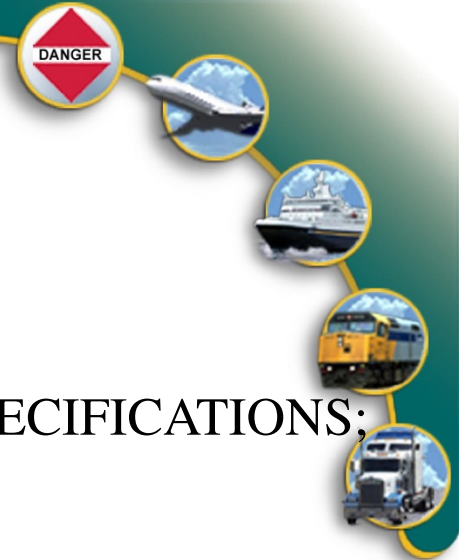
- ISSUES & ENFORCES TDG REGULATIONS & STANDARDS, TC
TANK CAR SPECIFICATIONS; MAINTENANCE & USE

INDUSTRY OVERSIGHT:

US/CANADA: ASSOCIATION OF AMERICAN RAILROADS (AAR)

- RAILROAD INTERCHANGE RULES; MSRP SECTION C-III
DETAILED TANK CAR SPECIFICATIONS

-ITS TANK CAR COMMITTEE HAS FEDERALLY DELEGATED
POWERS:APPROVES DESIGNS & COMPONENTS





ACCIDENT AND SAFETY ISSUES DRIVING CHANGES 1958-1979

PUNCTURES/FIRES/BLEVES/OTHERS

SERIES OF DISASTROUS RAILROAD ACCIDENTS INVOLVING
MAINLY CLASS 112A & 114A NON-INSULATED LPG PRESSURE
TANK CARS

BY 1975: 192 ACCIDENTS INVOLVING 432 112A OR 114A TANK
CARS; 156 LOSS OF LADING:

-68 HEAD PUNCTURES; 13 SHELL PUNCTURES; 59 TANK
RUPTURES

-29 KILLED; 936 INJURED

ALSO: FREQUENT BUCKLING OF NON PRESSURE TANK CARS



BLEVE DEFINITION: HOT, COLD

FOR THE PURPOSE OF
THIS PRESENTATION:



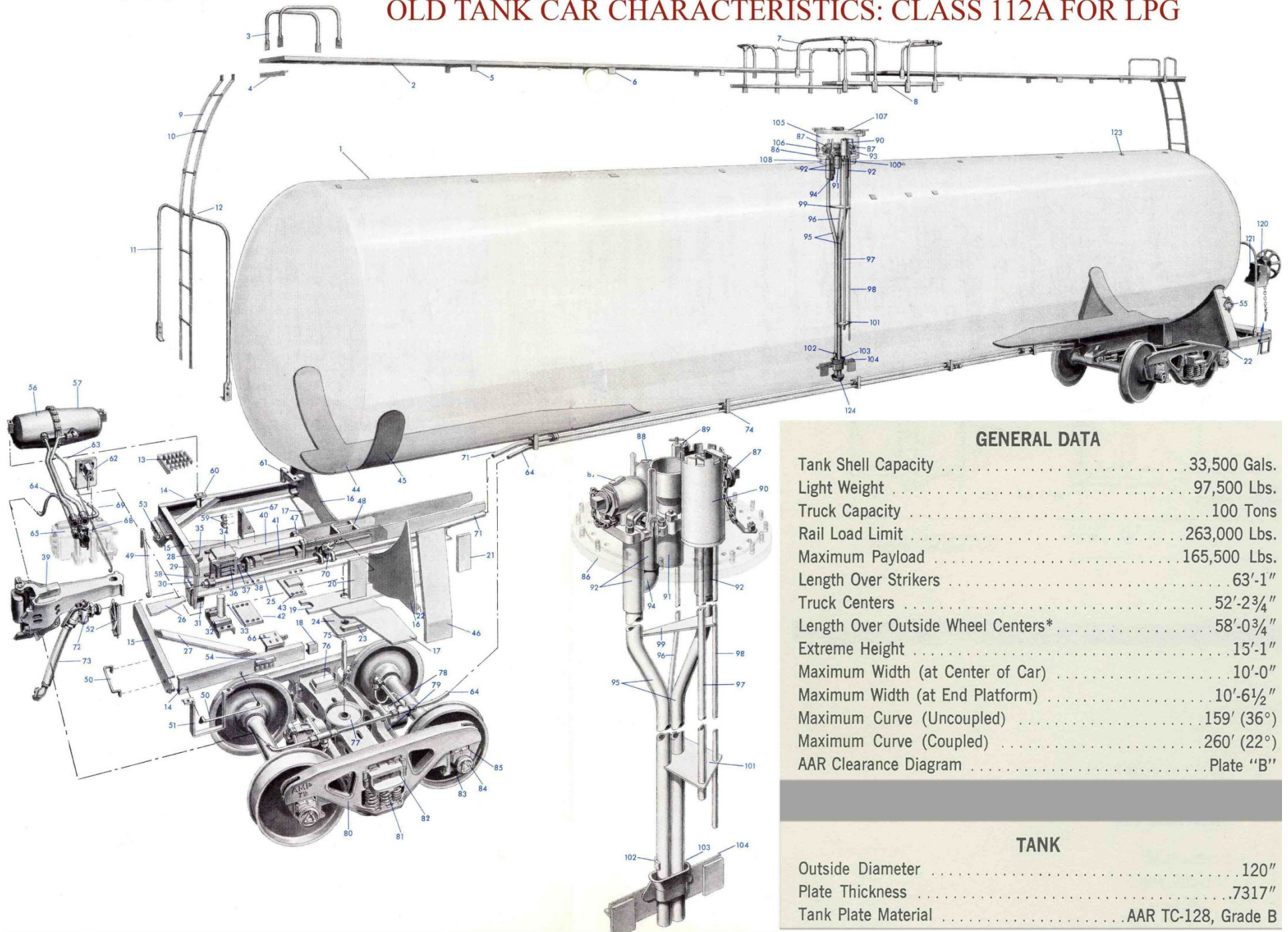
BLEVE: BOILING LIQUID EXPANDING VAPOR EXPLOSION

HOT BLEVE: CATASTROPHIC FAILURE OF THE TANK INDUCED BY FIRE FOLLOWED BY THE EXPLOSIVE RELEASE OF BOILING LIQUID AND EXPANDING VAPOR

COLD BLEVE: CATASTROPHIC FAILURE OF THE TANK WITH IMMEDIATE RELEASE OF CONTENTS. FAILURE OCCURS WHEN TANK IS WEAKENED BY SEVERE MECHANICAL DAMAGE CAUSED BY ACCIDENT, SOMETIMES AGGRAVATED BY COLD TEMPERATURE, CORROSION, EXISTING DEFECTS OR LESS DESIRABLE MATERIAL PROPERTIES: BRITTLE FAILURES.



OLD TANK CAR CHARACTERISTICS: CLASS 112A FOR LPG



GENERAL DATA

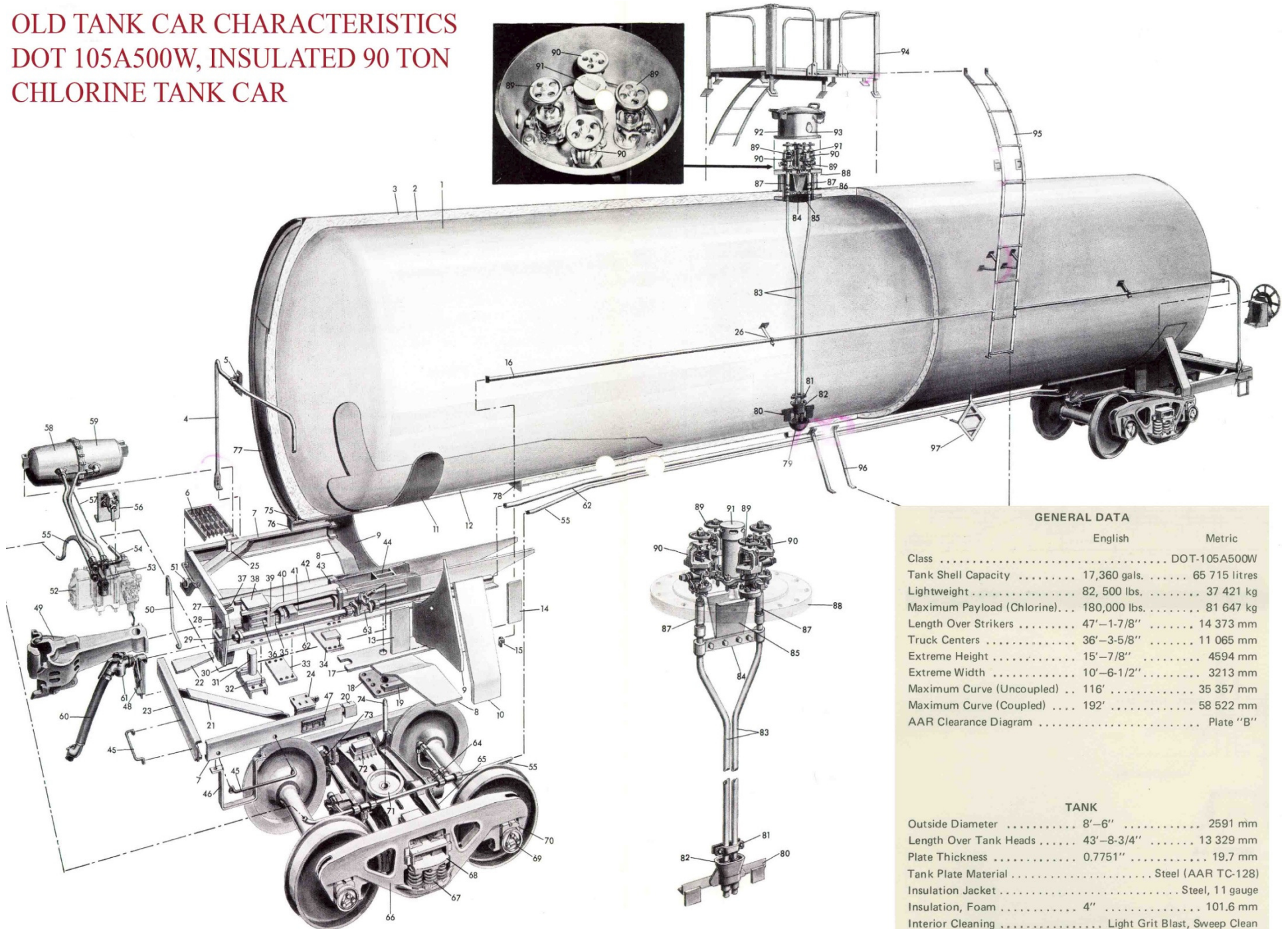
Tank Shell Capacity	33,500 Gals.
Light Weight	97,500 Lbs.
Truck Capacity	100 Tons
Rail Load Limit	263,000 Lbs.
Maximum Payload	165,500 Lbs.
Length Over Strikers	63'-1"
Truck Centers	52'-2 ³ / ₄ "
Length Over Outside Wheel Centers*	58'-0 ³ / ₄ "
Extreme Height	15'-1"
Maximum Width (at Center of Car)	10'-0"
Maximum Width (at End Platform)	10'-6 ¹ / ₂ "
Maximum Curve (Uncoupled)	159' (36°)
Maximum Curve (Coupled)	260' (22°)
AAR Clearance Diagram	Plate "B"

TANK

Outside Diameter	120"
Plate Thickness7317"
Tank Plate Material	AAR TC-128, Grade B

OLD TANK CAR CHARACTERISTICS

DOT 105A500W, INSULATED 90 TON CHLORINE TANK CAR



GENERAL DATA

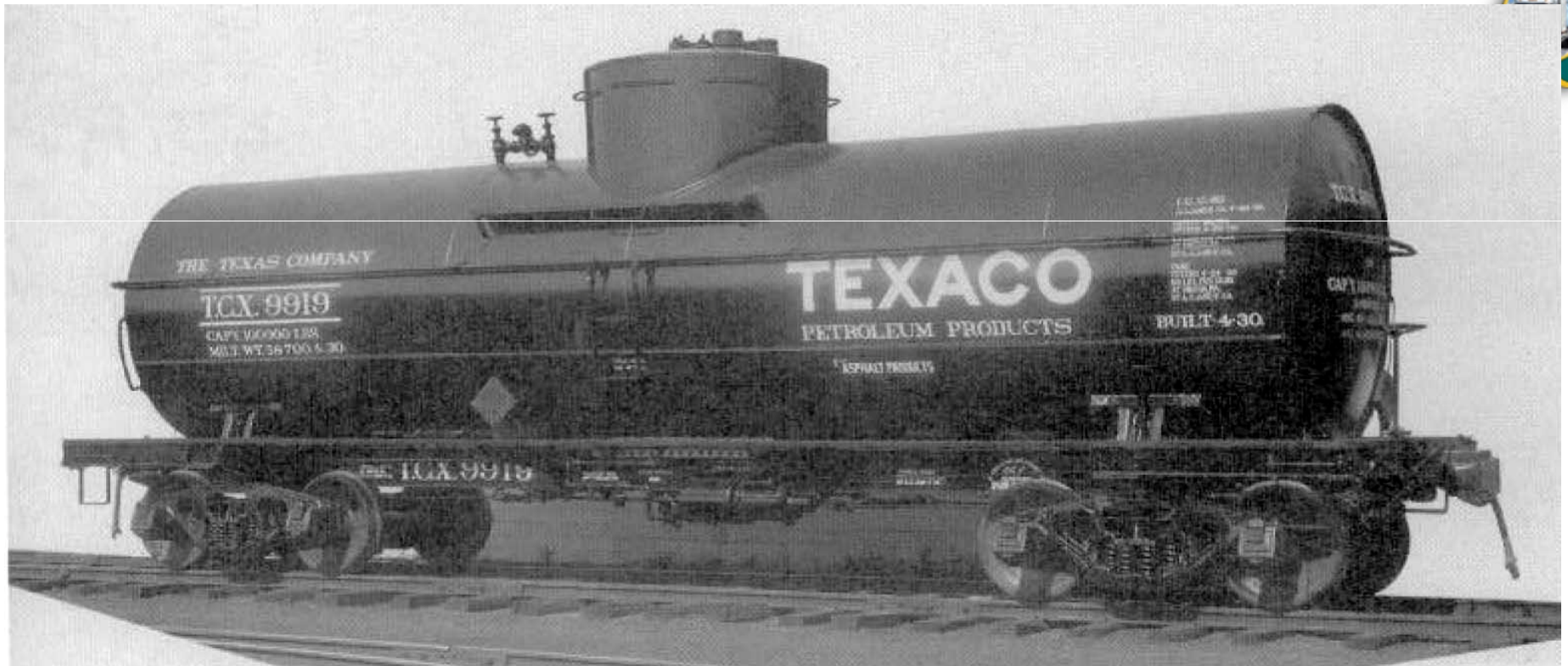
	English	Metric
Class		DOT-105A500W
Tank Shell Capacity	17,360 gals.	65 715 litres
Lightweight	82, 500 lbs.	37 421 kg
Maximum Payload (Chlorine)	180,000 lbs.	81 647 kg
Length Over Strikers	47'-1-7/8"	14 373 mm
Truck Centers	36'-3-5/8"	11 065 mm
Extreme Height	15'-7/8"	4594 mm
Extreme Width	10'-6-1/2"	3213 mm
Maximum Curve (Uncoupled)	116'	35 357 mm
Maximum Curve (Coupled)	192'	58 522 mm
AAR Clearance Diagram		Plate "B"

TANK

Outside Diameter	8'-6"	2591 mm
Length Over Tank Heads	43'-8-3/4"	13 329 mm
Plate Thickness	0.7751"	19.7 mm
Tank Plate Material		Steel (AAR TC-128)
Insulation Jacket		Steel, 11 gauge
Insulation, Foam	4"	101.6 mm
Interior Cleaning		Light Grit Blast, Sweep Clean



OLD TANK CAR STYLE: SPECIFICATION ICC 103 NON PRESSURE TANK CAR NOTICE EXPANSION DOME ON TOP





RESEARCH & OTHER SAFETY INITIATIVES (PRE 1980)

- IN 1969 RPI/AAR COOPERATIVE PROJECT ESTABLISHED TO IMPROVE TANK CAR SAFETY IN ACCIDENTS
- MAJOR ACCIDENTS & TANK CAR FAILURES WELL DOCUMENTED
- DEVELOPMENT OF E & F TOP & BOTTOM SHELF COUPLERS
- HEAD PUNCTURE STUDIES: DROP TESTS; 1/5 SCALE & FULL SCALE; EVALUATE DEGREE OF PROTECTION OF VARIOUS OPTIONS.
- SWITCHYARD IMPACT TESTS (1979): ASSESS EFFECTIVENESS OF HEAD SHIELDS + SHELF COUPLERS: FULL SCALE DESTRUCTIVE TESTS OF 22 TANK CARS (112A, 33000 USG) & 15 HOPPER CARS
- ANALYSIS OF 112A340W TANK CAR IN STANDARD HEAT FLUX
- SEVEN 1/5 & 2 FULL SCALE POOL FIRE TESTS IN WHITE SANDS: NON-INSULATED RAX 201 & SPRAY ON THERMALLY PROTECTED RAX 202
- IDENTIFICATION OF FIRE RESISTANT SYSTEMS





NEW SAFETY SYSTEMS DEVELOPED BY MID 1980s

-TANK HEAD PUNCTURE RESISTANCE SYSTEMS:

FULL AND HALF HEAD SHIELDS

-TOP AND BOTTOM SHELF COUPLERS

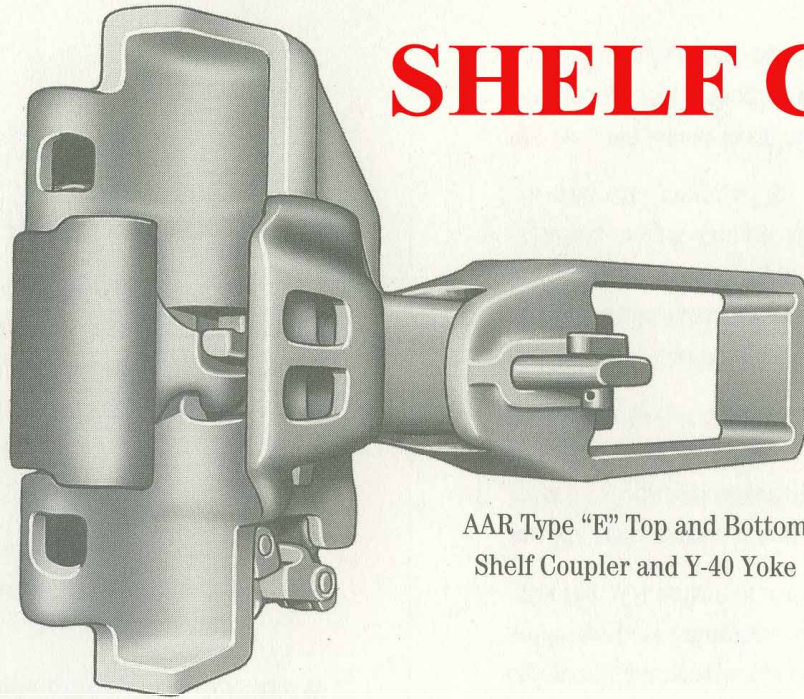
-BOTTOM DISCONTINUITY PROTECTION

-THERMAL PROTECTION SYSTEMS

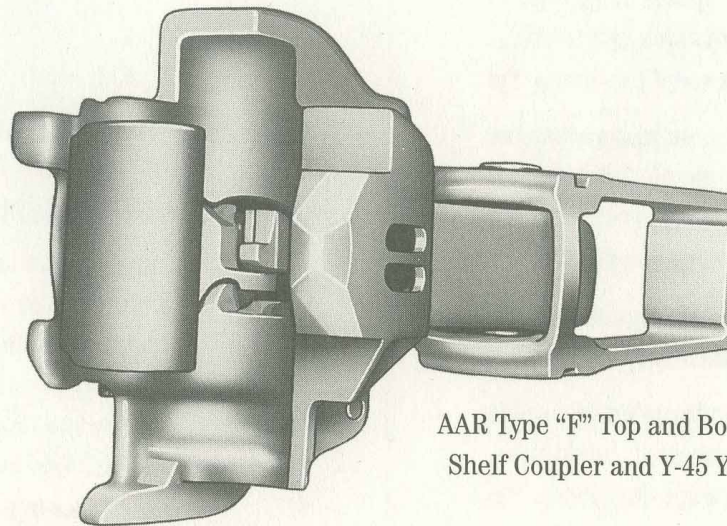
TESTS WERE DESIGNED TO VERIFY SYSTEM SURVIVABILITY



SHELF COUPLERS

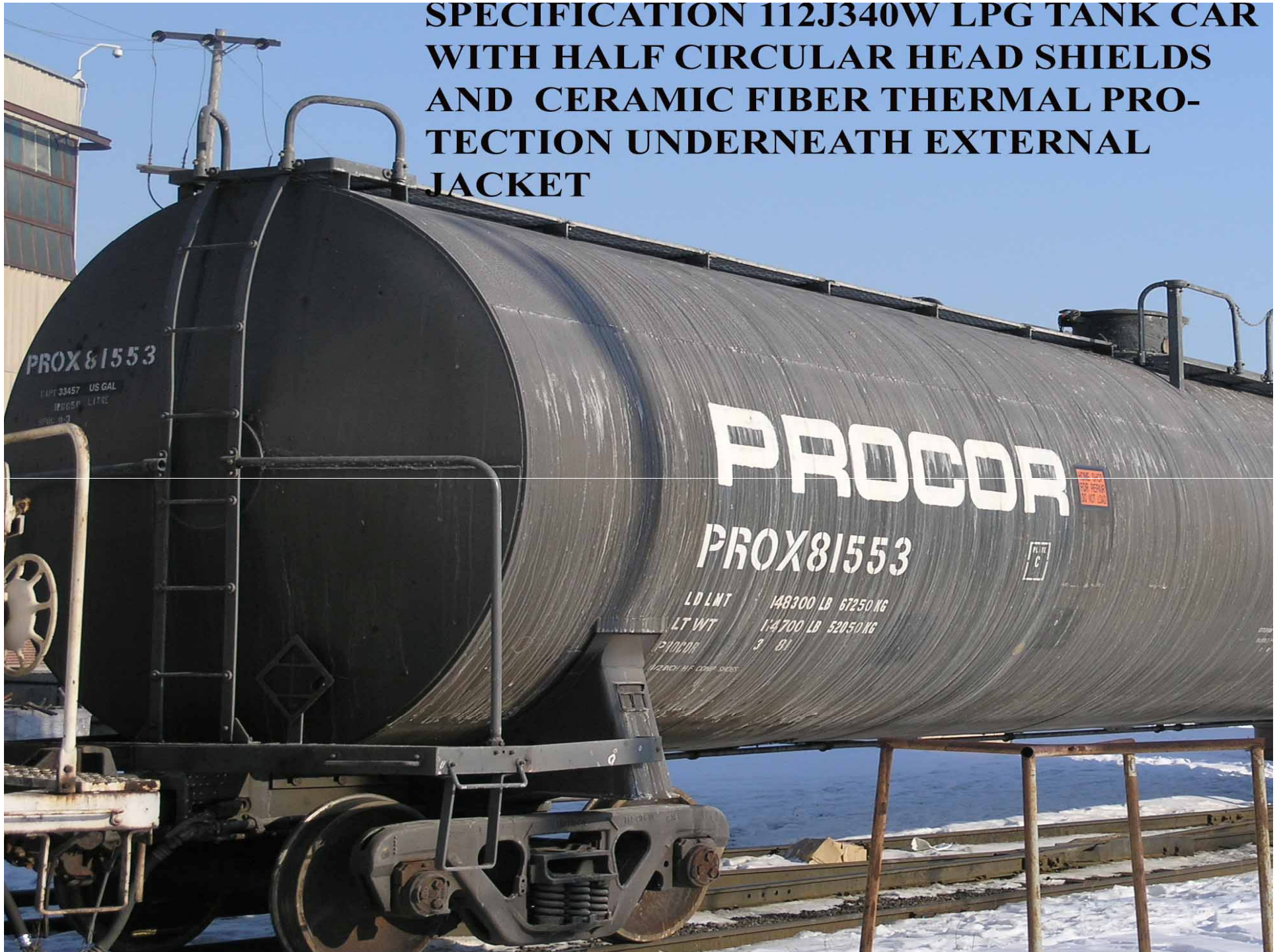


AAR Type "E" Top and Bottom
Shelf Coupler and Y-40 Yoke



AAR Type "F" Top and Bottom
Shelf Coupler and Y-45 Yoke

**SPECIFICATION 112J340W LPG TANK CAR
WITH HALF CIRCULAR HEAD SHIELDS
AND CERAMIC FIBER THERMAL PRO-
TECTION UNDERNEATH EXTERNAL
JACKET**

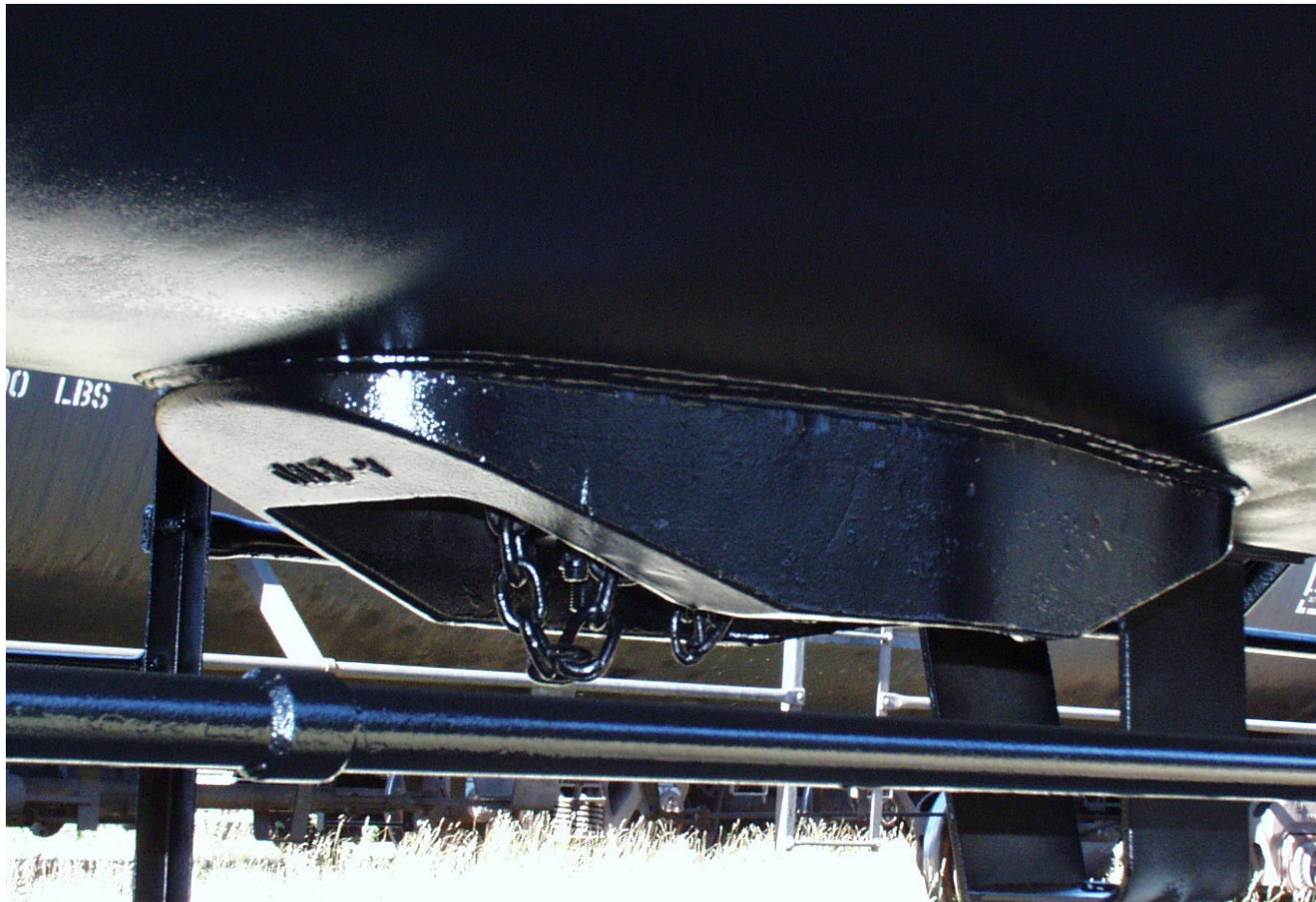


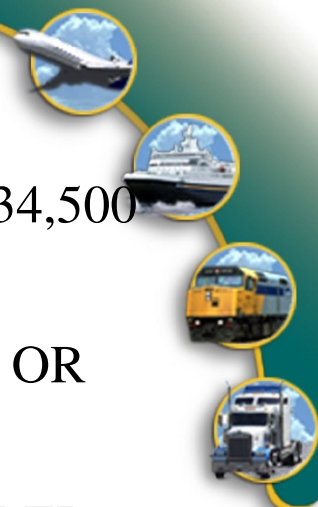
**SPECIFICATION 112T340W TANK CAR EQUIPPED WITH
TRAPEZOIDAL HALF HEAD SHIELD, SPRAY ON THERMAL
PROTECTION AND SHELF COUPLERS**





BOTTOM DISCONTINUITY PROTECTION





PRESCRIBED SAFETY IMPROVEMENTS UNTIL MID 1980s

-MAX GROSS WEIGHT & VOLUME PRESCRIBED: 263,000 LBS & 34,500 USG (1970)

-STUB SILL TO PAD WELD CONNECTION STRENGTH TO BE 85% OR LESS OF PAD TO TANK WELD CONNECTION (AAR 1971)

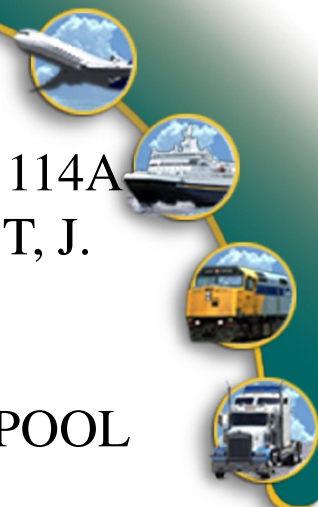
-FLAMMABLE GAS TANK CARS: EXCESS FLOW VALVES REQUIRED UNDER LOADING/UNLOADING/SAMPLING VALVES & VERTICAL DISCHARGE FROM SAFETY VALVE (1971)

-CHLORINE TANK CARS: EXCESS FLOW VALVES REQUIRED UNDER LIQUID VALVES (1971)

-TRAIN SPEED/TANK CAR PLACEMENT: VARIOUS RULES REQUIREMENTS OVER THE YEARS: MARSHALING TABLES.

-HALF HEAD SHIELDS REQUIRED ON 112A AND 114A BY JAN 1 1978 TO INCREASE PUNCTURE SPEED. SPREAD THE LOAD, BLUNT STRIKING EDGE OF IMPACTING OBJECTS. MUST SURVIVE COUPLER TO TANK IMPACTS OF 29 KM/H (18 MPH)





PRESCRIBED SAFETY IMPROVEMENTS UNTIL MID 1980s

-THERMAL PROTECTION & HALF HEAD SHIELDS ON 112A AND 114A IN CLASS 2.1 SERVICE BY 1981. SPEC BECAME 112S,T, J OR 114S,T, J.

-INCREASED DESIGN LOADS/FATIGUE DESIGN/DATA (1974-80s)

-THERMAL PROTECTION SYSTEMS HAD TO BE QUALIFIED BY POOL & TORCH FIRE TESTS

-BOTTOM DISCONTINUITY PROTECTION (PHASED IN)

-TOP AND BOTTOM SHELF COUPLERS REQUIRED ON ALL DG TANK CARS (PHASED IN STARTING EARLY 1980)

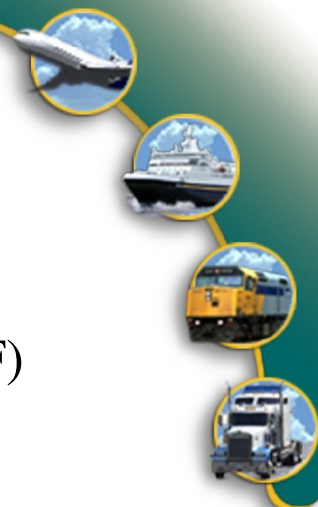
-THERMAL PROTECTION HAD TO:

PREVENT RUPTURE FOR 100 MIN IN POOL FIRE

PREVENT RUPTURE FOR 30 MIN IN TORCH FIRE.

ANALYSIS REQUIRED FOR TANK CAR (ACCOUNT FOR CAR PARTICULARS, COMMODITY, PRV, HEAT SINKS, ETC)





THERMAL PROTECTION SPECIAL CONCERN: CHLORINE GAS

REACTION BETWEEN DRY Cl_2 AND STEEL

NEED TO MAINTAIN STEEL WALL TEMPERATURE $< 250^{\circ}C$ ($483^{\circ}F$)
DURING:

30 MIN TORCH FIRE; &

100 MIN POOL FIRE

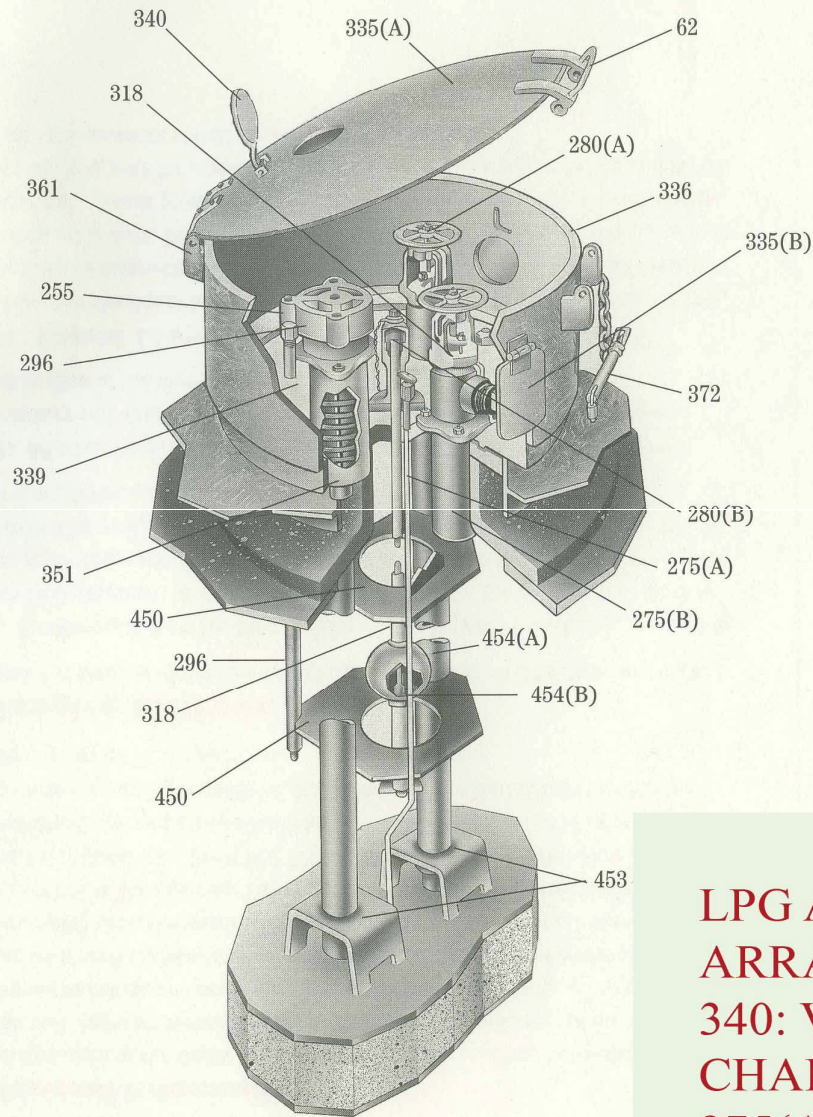
SPECIFIC RESEARCH & TESTS PERFORMED TO IDENTIFY
ADEQUATE TANK CAR INSULATION & THERMAL PROTECTION
SYSTEMS: CALIBRATED FIRE TESTS ON SAMPLES

RECENT CHLORINE 105 CLASS TANK CARS EQUIPPED WITH 2
INCH CERAMIC ON TANK COVERED WITH 2 INCH FIBERGLASS &
EXTERNAL STEEL JACKET





PRESCRIBED SAFETY IMPROVEMENTS UNTIL MID 1980s



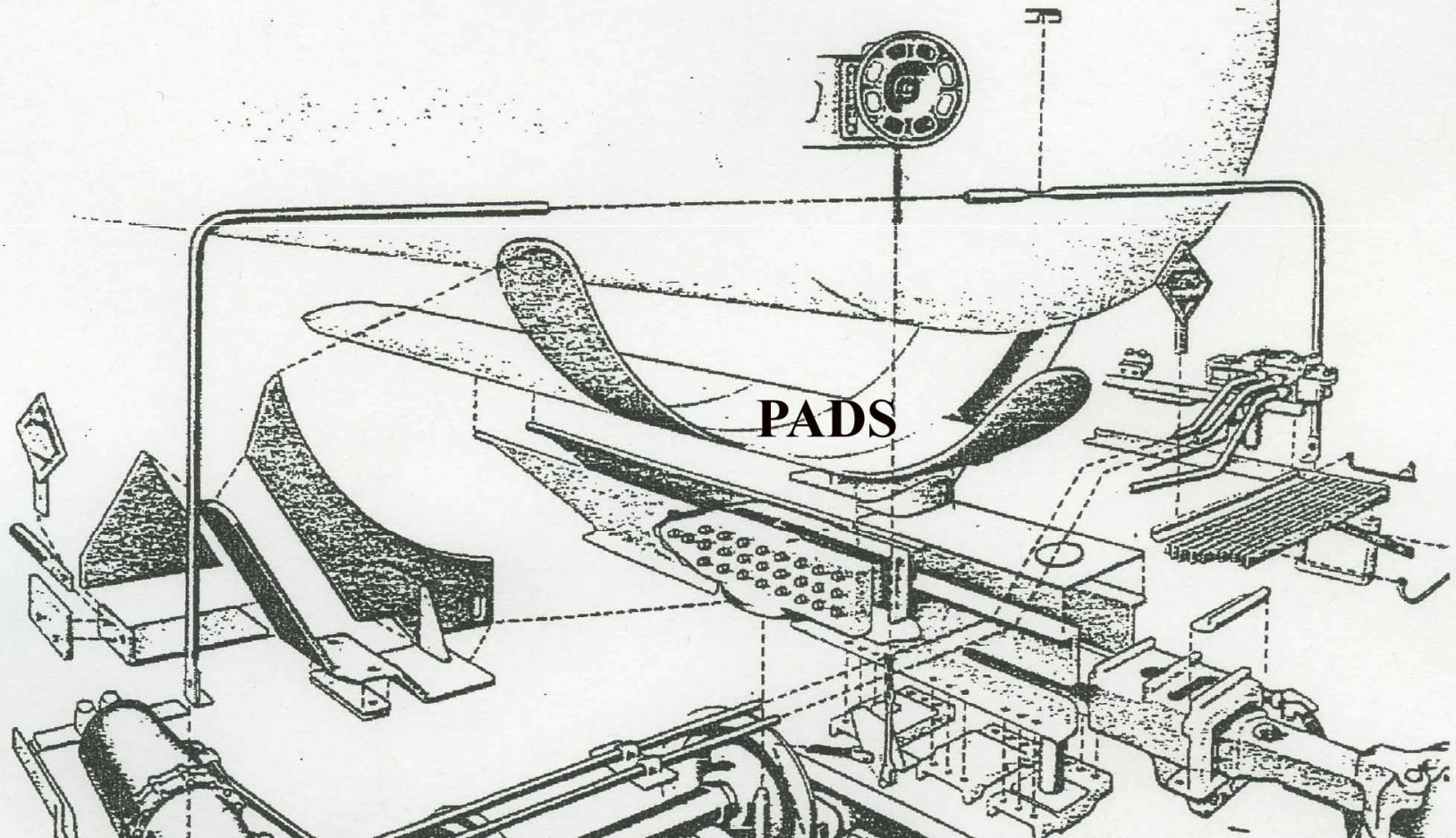
Part No.	Description
62	Bonnet Cover Handle
255	Safety Valve Assembly
275(A)	1/4" Check Valve
275(B)	3" Check Valve
280(A)	2" Angle Valve
280(B)	1/4" Angle Valve
296	Thermometer Well
318	Gauging Device Assembly
335(A)	Manway Bonnet Cover
335(B)	Manway Bonnet Side Cover
336	Manway Bonnet
339	Manway Cover Plate
340	Vent Cover
351	Manway Nozzle
361	Hinge
372	Seal Pin
450	Pipe Bracket
453	Pipe Guide
454(A)	Discharge Pipe
454(B)	Test/Sample Pipe

**LPG AND NH3 LOADING AND UNLOADING ARRANGEMENT. NOTE ITEMS:
340: VENT COVER ALLOWS VERTICAL DISCHARGE FROM SAFETY VALVE
275(A&B) EXCESS FLOW VALVES**

PRESCRIBED SAFETY IMPROVEMENTS UNTIL MID 1980s



**STUB SILL TO PAD WELD CONNECTION
STRENGTH TO BE 85% OR LESS OF PAD TO
TANK WELD CONNECTION**



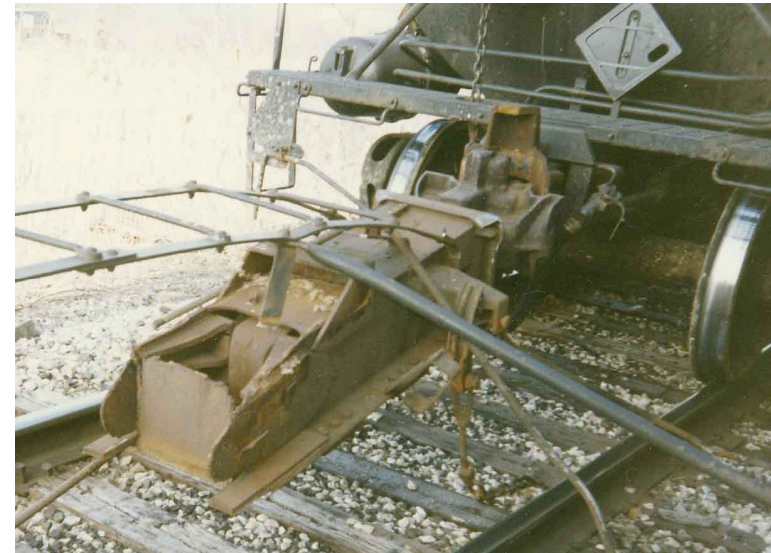


EXPERIENCE GAINED FROM 1985-2006

ACCIDENTS

- OCCURRENCE OF HOT BLEVES GREATLY REDUCED
- HALF HEAD SHIELD PERFORMANCE: GOOD BUT HEAD PUNCTURES IN TOP HALF OCCURRED OCCASIONALLY
- COLD BLEVES OCCURRED OCCASIONALLY. EX: MINOT, NORTH DAKOTA, JAN 2002. MULTIPLE TANK FAILURES, 800,000 L OF ANHYDROUS AMMONIA RELEASED.

- STUB SILL CRACKING AND FAILURES:





EXPERIENCE GAINED FROM 1985-2006 ACCIDENTS

-TANK AND STUB SILL FAILURES CAUSED BY UNDETECTED CRACKS THAT GREW TO FAILURE. A NOTABLE COLD BLEVE: DRAGON, MISSISSIPPI, EARLY 1990s, FULL LPG TANK CAR BROKE IN HALF

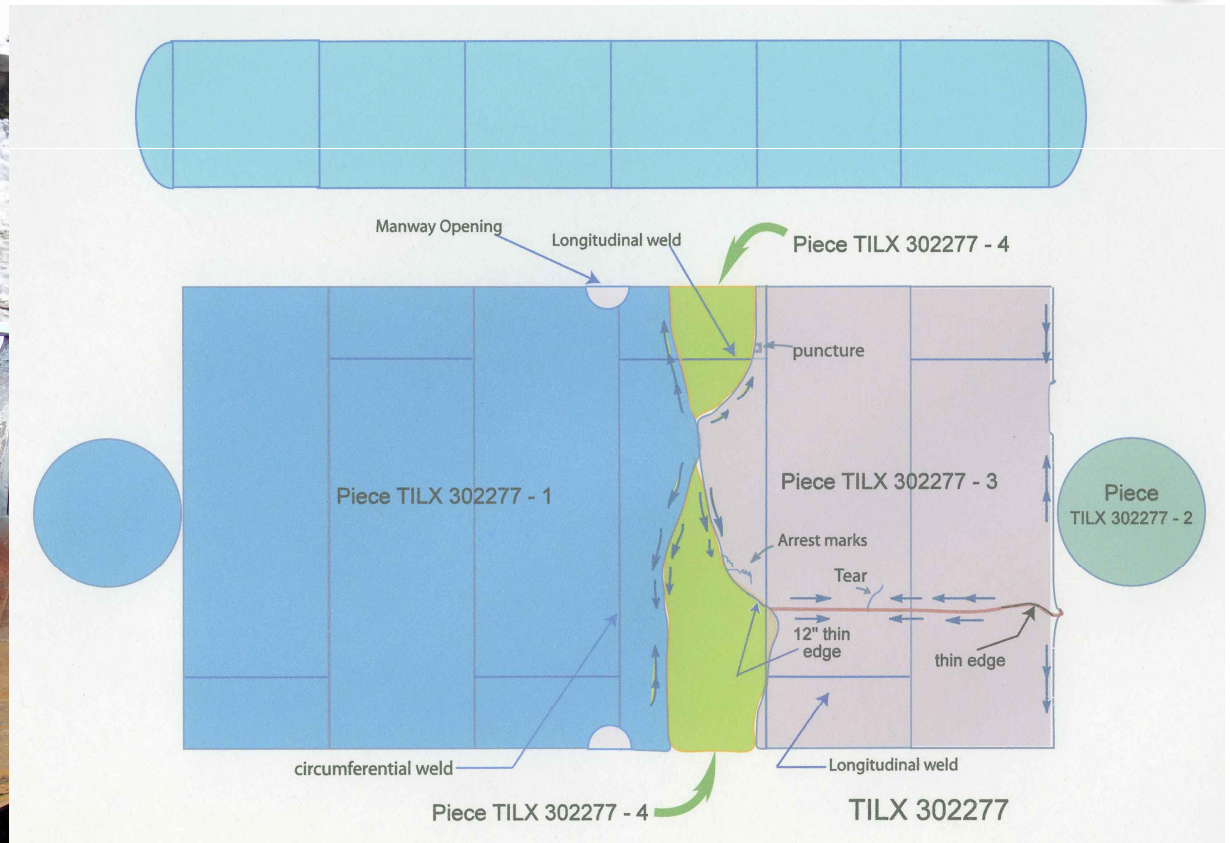
SIMILAR FAILURE:
SULPHURIC ACID TANK CAR





EXPERIENCE GAINED FROM 1985-2006 ACCIDENTS

-SOME HOT BLEVES OCCURRED IN LESS THAN 100 MINUTES. TC INVESTIGATED SOME IN CANADA. ISSUES: MECHANICAL DAMAGE; SAFETY VALVE CAPACITY; OLD STEELS, THERMAL PROTECTION DEGRADATION





EXPERIENCE GAINED FROM 1985-2006

SPECIFIC PROBLEMS & LESSONS LEARNED

-WORKMANSHIP QUALITY SOMETIMES SUBSTANDARD DURING MANUFACTURING, REPAIR & MAINTENANCE. OFTEN A CAUSAL FACTOR IN FAILURES

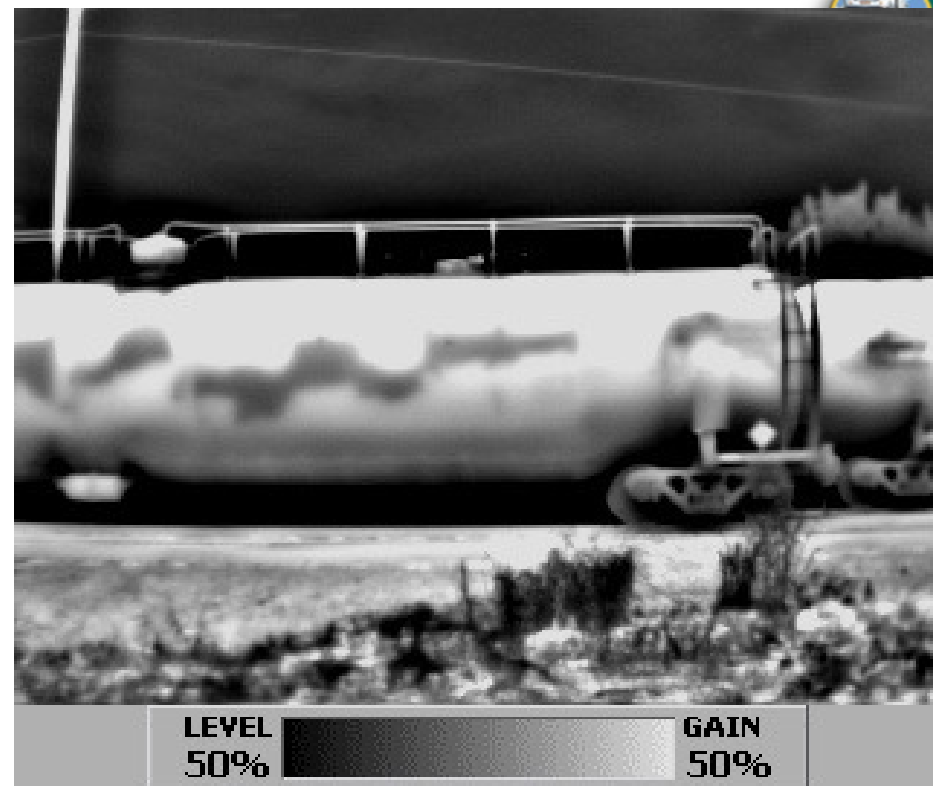
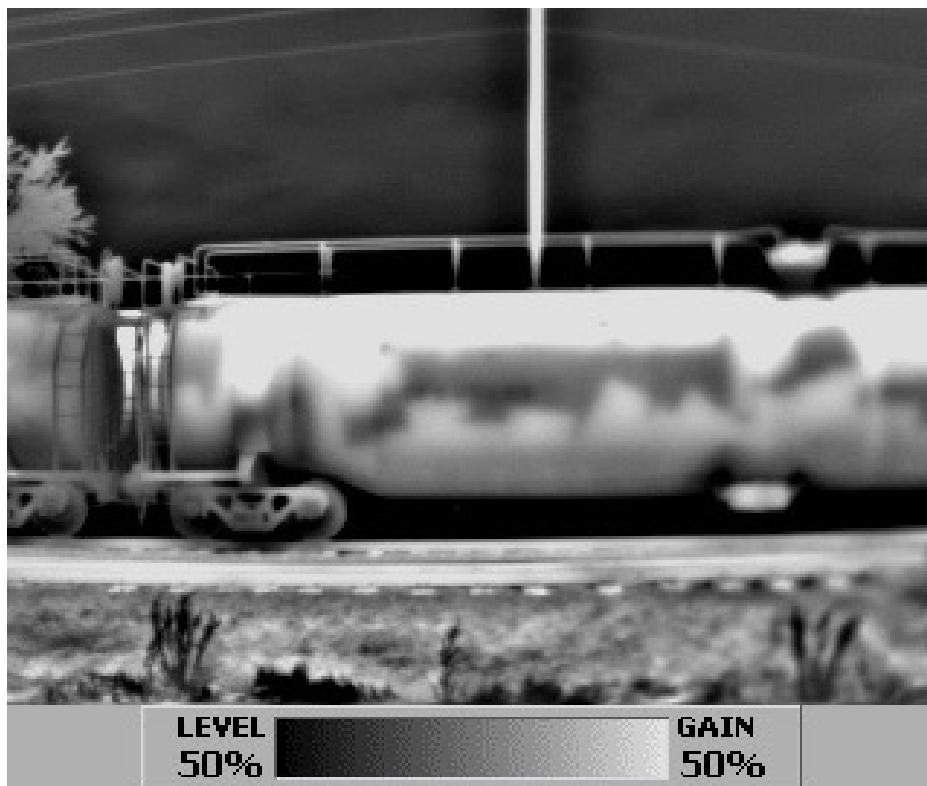
-DOUBLE SHELF COUPLERS ALSO HAS DISADVANTAGES. SOMETIMES STRING OF “EMPTY” TANK CARS DERAIL:





EXPERIENCE GAINED FROM 1985-2006 SPECIFIC PROBLEMS & LESSONS LEARNED

-THERMAL PROTECTION SYSTEM DEGRADATION



EXPERIENCE GAINED FROM 1985-2006 SPECIFIC PROBLEMS & LESSONS LEARNED



DAMAGE TO THERMAL PROTECTION SYSTEM DURING AN ACCIDENT





EXPERIENCE GAINED FROM 1985-2006

SIGNIFICANT SUBSEQUENT REGULATIONS AND REQUIREMENTS

- NORMALIZING OF PRESSURE TANK CAR STEELS (1989 TO NOW)
- OLDER STEEL PROHIBITED FOR NEW CONSTRUCTION (ONLY 516-70 & AAR TC-128B REMAIN)
- THERMAL PROTECTION REQUIRED ON ALL TANK CARS FOR CLASS 2 GASES EXCEPT CRYOGENICS BY JULY 2006
- FULL HEAD PROTECTION REQUIRED ON ALL RECENT TANK CARS FOR CLASS 2 GASES, & AL OR NICKEL TANKS; EXCEPT 105J500W/600W
- PERIODIC HYDROSTATIC RETEST REPLACED BY QUALIFICATION: TANK STRUCTURAL INTEGRITY INSPECTION BY NDT TECHNIQUES, SAFETY SYSTEMS INSPECTION (THERMAL PROTECTION, HEAD SHIELDS, ETC), THICKNESS TESTS, SERVICE EQUIPMENT.10 YEARS MAX
- QUALITY ASSURANCE REQUIREMENTS FOR TANK CAR FACILITIES
- TANK CAR FACILITIES TO BE REGISTERED WITH TRANSPORT CANADA





EXPERIENCE GAINED FROM 1985-2006

SIGNIFICANT SUBSEQUENT REGULATIONS AND REQUIREMENTS

- SOME LIQUID TIH PROHIBITED IN 103 & 111 TANK CARS: MIN 300 PSI TP; HEAD PROTECTION & JACKET (MID 1990s)
- HAZ SUBSTANCES (HALOGENATED COMPOUNDS) PROHIBITED FROM 103 & 111 TANK CARS: 200 PSI TP OR 340 PSI (MID 1990s)
- FRACTURE MECHANICS FEA/DTA METHODOLOGIES DEVELOPED
- STUB SILL REINSPECTIONS: MIN 10 YEARS & OTHER CRITERIA
- SULPHURIC ACID TOP FITTINGS PROTECTION (10 YRS: BY AUG 2011)
- MOLTEN SULPHUR TANK CARS: CORROSION PROTECTION (10 YRS: BY 2004)
- TANK CARS OVER 263K TO 286K: BY TC/DOT PERMIT ONLY. TC/FRA WHITE PAPER SPELLED OUT ENHANCED SAFETY REQUIREMENTS FOR SUCH TANK CARS.



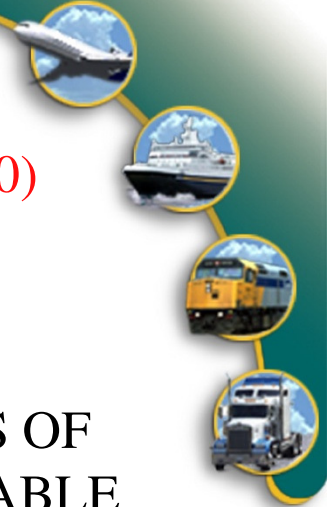


EXPERIENCE GAINED FROM 1985-2006

RESEARCH:

- METHODOLOGY DEVELOPED FOR FINITE ELEMENT/ DAMAGE TOLERANCE ANALYSIS (FEA/DTA) OF TANK CAR STRUCTURAL COMPONENTS (MID 1990s)(TANK & STUB SILLS)
- PROBABILITY OF DETECTION (POD) OF VARIOUS NDT TECHNIQUES (ONGOING)
- ACOUSTIC EMISSION TESTING PROCEDURE FOR INSPECTION OF TANK CAR TANK AND STUB SILLS
- THERMOGRAPHY AS AN INSPECTION TOOL TO IDENTIFY INSULATION AND THERMAL PROTECTION DEFECTS. ACCEPT/REJECT CRITERIA
- DEVELOPMENT OF AFFTAC (US DOT FRA). PROGRAM TO ANALYZE FIRE EFFECTS ON TANK CARS. PREDICTS TIME TO FAILURE.





EXPERIENCE GAINED FROM 1985-2006 RESEARCH

TRANSPORT CANADA FUNDED BLEVE RESEARCH (SINCE 1990)

-LPG CONTAINERS OF ALL SIZES WERE STUDIED. TESTS ON TANKS UP TO 500 US GALLONS.

-USE OF THERMOGRAPHY AS AN INSPECTION TOOL. EFFECTS OF THERMAL PROTECTION DEGRADATION ON SAFETY. ACCEPTABLE LEVELS OF DEGRADATION.



-MANY REPORTS ISSUED AND AVAILABLE. ALSO A BLEVE VIDEO





MORE RECENT LPG & NH3 TANK CAR

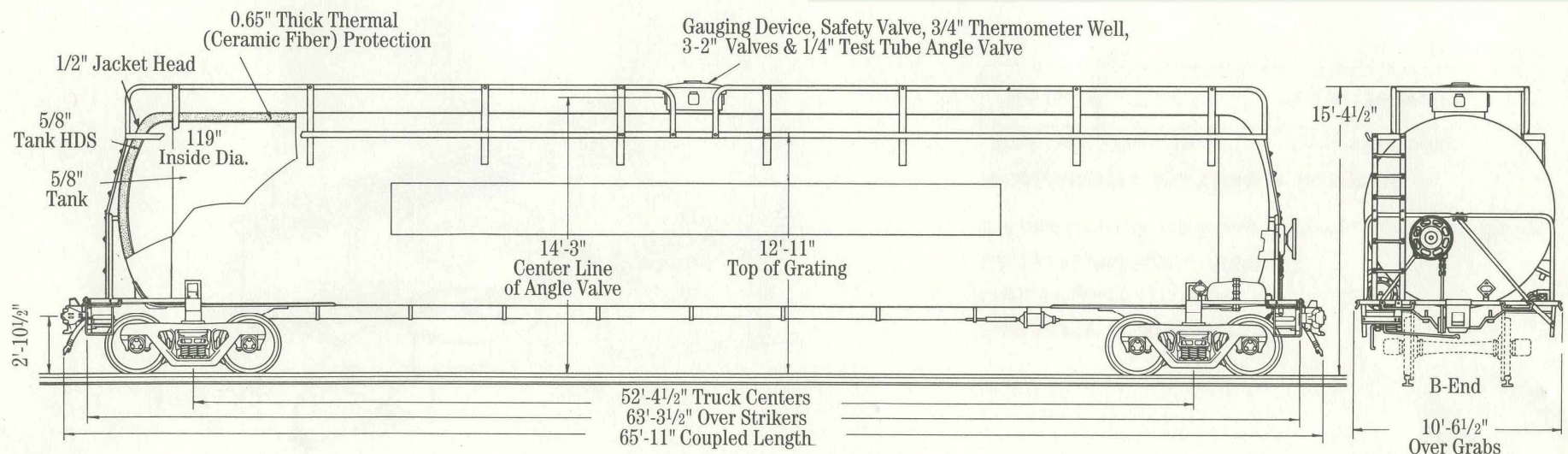
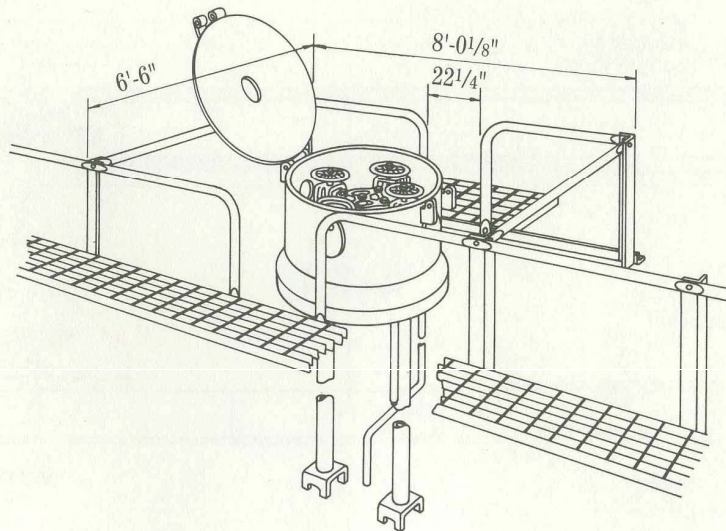
33,500 GALLON CAPACITY - NON-INSULATED - THERMAL PROTECTED

DOT-112J340W

For Liquefied Petroleum Gas & Anhydrous Ammonia Service

FEATURES

- THERMAL PROTECTION
- DOUBLE SHELF COUPLERS
- FULL 1/2 IN STEEL HEAD SHIELDS
- AAR TC 128B NORMALIZED STEEL
- EXCESS FLOW VALVES AT ALL OPENINGS
- LARGE CAPACITY PRV @ 280 PSI
- TANK CAR QUALIFIED UNDER NEW FEDERAL REGULATIONS

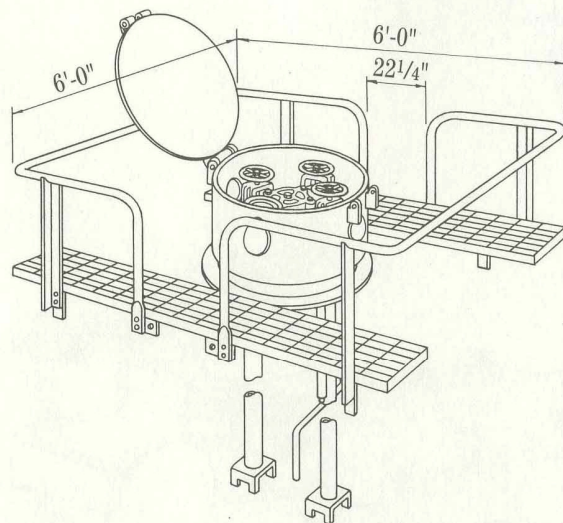
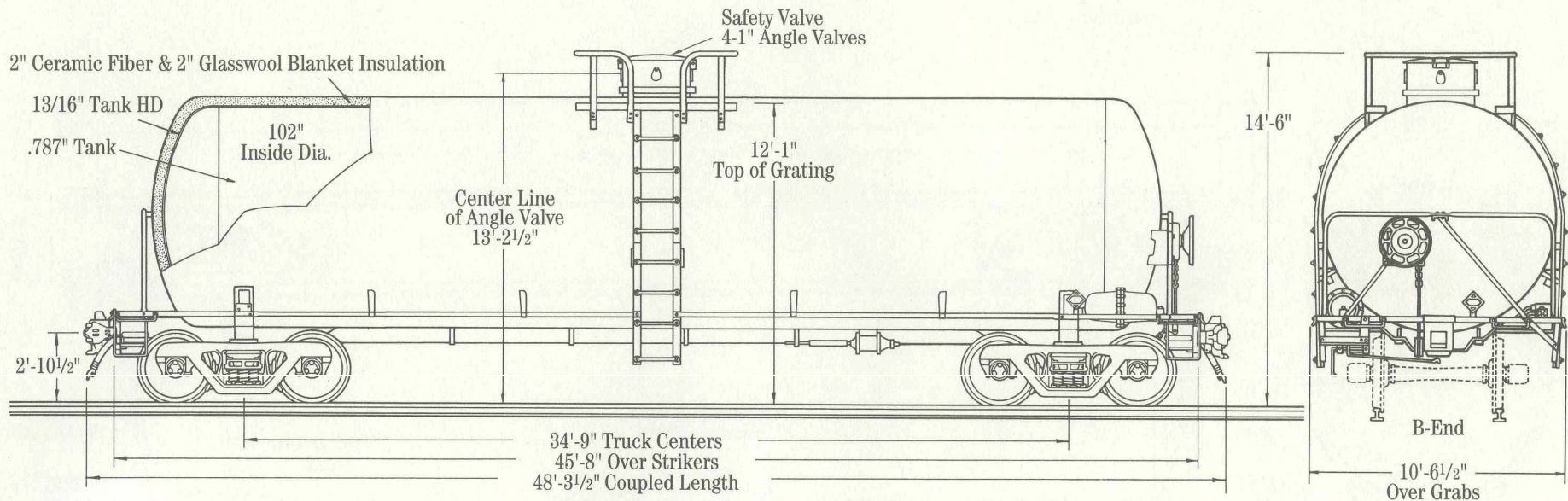


MORE RECENT CHLORINE TANK CAR



**90 TON CAPACITY - INSULATED -
THERMAL PROTECTED**

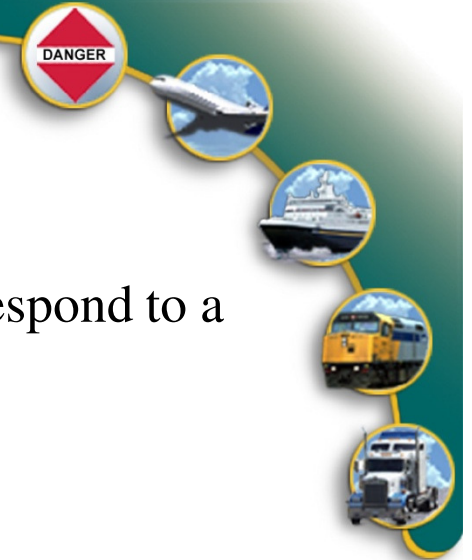
DOT-105S500W



FEATURES:

- SPECIAL THERMAL PROTECTION
- DOUBLE SHELF COUPLERS
- AAR TC 128B NORMALIZED STEEL
- PRESSURE RELIEF VALVE @ 375 PSI
- EXCESS FLOW VALVES @ LIQUID LINES
- TANK CAR QUALIFIED UNDER NEW FEDERAL REGULATIONS

SECURITY: RECENTLY AMENDED TDG ACT



Response

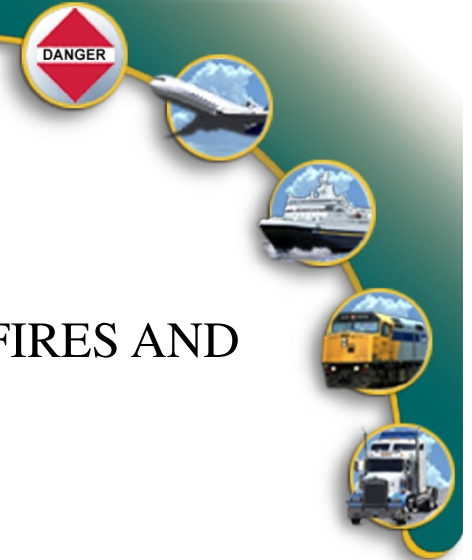
- Enabling the use of Emergency Response Assistance Plans to respond to a terrorist release of dangerous goods.
- Reinforcing the ERAP program.

Security Prevention

- Require security plans and security training;
- Require a transportation security clearance for the dangerous goods (e.g., truck drivers), as well as an appeals process (comparable to the existing Aeronautics Act clearance program);
- Enable the use of Security Measures and Interim Orders (as Public Safety Act and 10 other existing Parliament Acts); and
- Enable regulations to be made to require that dangerous goods are tracked during transport, or reported if lost or stolen.



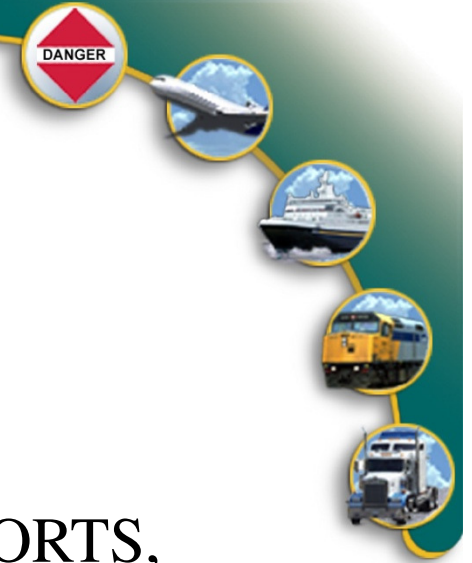
SUMMARY/CONCLUSIONS



- NUMEROUS WELL DOCUMENTED ACCIDENTS INVOLVING FIRES AND EXPLOSIONS OCCURRED DURING 50s, 60s & 70s
- RESEARCH UNDERTAKEN TO ADDRESS THE PROBLEM
- REGULATORY REQUIREMENTS TO IMPROVE THE TANK CAR FLEET INTRODUCED DURING 70s & EARLY 80s
- EXPERIENCE WAS GAINED DURING 80s & 90s.
- MANY DOCUMENTED ACCIDENT REPORTS DEMONSTRATE THE EFFECTIVENESS AND SHORTCOMINGS OF THE ENHANCEMENTS.
- NEW CONCERNS IN THE 90s: CRACKS, DTA, RELIABILITY OF SYSTEMS, QA, COLD PROPERTIES OF STEELS, PUNCTURE RESISTANCE.
- NEW REGULATIONS ISSUED IN THE MID 90s TO ADDRESS THESE CONCERNS



QUESTIONS??



CONTACT FOR FURTHER INFO/ COPIES OF REPORTS,
BLEVE VIDEO, REGS, PICTURES, ETC.:

JEAN-PIERRE GAGNON: Jean-pierre.gagnon@tc.gc.ca

PHONE: 613 998-5267

