

Steam Association of Manitoba

Course Topics for Steam Traction Engine Steam School

Revision1: April 2017

Revision 2 April 2024

File name: SAM Steam School Curriculum 2024

Revision 3 April 2026

File name: SAM Steam School Curriculum 2026

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1. Preamble

1.1 Scope

The program is aimed at entry-level engineers.

Steam school is a key part of providing important information about steam traction engines, their safe operation and management along with an overview of the role of agencies, steam organizations, inspectors and licensed shops that need to be part of a new engineer's frame of reference today.

1.2 Licensing Requirements

Licensing of Steam Traction Engineers in Manitoba requires:

- steam school organized and presented by the Steam Association of Manitoba (SAM) with instructors who are members of SAM. SAM might invite members from steam associations in other provinces or states to help instruct.
- one hour experience credit for each steam school hour plus...
- at least 80 hours with a variety of hands-on experience signed off by licensed Steam Traction Engineers.
- An ITS affidavit specifying steam experience activities
- written exam
- driver's test

1.3 Hands-on Experience

The type of practical experience is important. The qualified engineer signing off a candidate's hours should be ensuring that a wide variety of practical experience in steam traction engine operation and maintenance. Student engineers should be able to:

1. check for water in boiler and reservoir tank/s prior to startup
2. conduct a complete walk around (inspection) of the engine prior to fire up
3. inspect and install an ASME fusible plug
4. install hand holes
5. clean tubes, grates, smoke box and ash pan
6. lubricate the whole steam traction engine with the appropriate lubricants.
7. set valves and controls in appropriate positions before firing
8. bring engine up to operating pressure from a cold start
9. prove a water gauge glass with a boiler under pressure
10. operate try cocks
11. control fire to maintain appropriate pressure
12. operate injectors and/or pumps to maintain appropriate water level
13. know governor operation, lubrication, adjustment and belt maintenance
14. start, stop and maneuver the steam traction engine on level and sloping ground
15. belt up to a pulley
16. conduct an emergency shutdown
17. conduct a safe blow down
18. drain, wash and prepare boiler for storage
19. prepare boiler for inspection: internal, hydrostatic

1.4 Cautions and Competence

The accumulated hours along with steam school and a licensing exam is not enough. The licensed engineer providing the practical training must make a judgment with his/her signature testifying not just to the candidate's hours of experience, but that the candidate would make for a competent engineer.

2. Course Outline

2.1 Parts of a Steam Traction Engine

- Terms and Definitions

2.2 Properties of Water and Steam

- phases of water
- heating water in the open vs. in a pressure vessel

- definition of BTU
- water to steam
 - latent heat of vaporization
 - wet steam
 - dry steam
 - superheated steam
- pressure
 - atmospheric pressure
 - pressure gauge
 - psi and PSIG
 - velocity and pressure (venturi)
 - temperature and pressure
- expansive properties of steam
- flashover

2.3 Boiler Design and Construction

2.3.1 Types of Boilers

- Fire tube
 - Vertical Tube Boiler
 - Wet top
 - Dry top
 - Return Flue
 - Locomotive
 - Wet bottom
 - Dry bottom
- Water tube
 - e.g. Bryan Tractor

2.3.2 Five safety features on a boiler:

- Water gauge glass
 - components
 - water column
 - checking water with no boiler pressure
- Try cocks
 - what the try cocks do
- Steam Pressure Gauge
 - operating pressure range recommended
 - types of siphons

- steam pressure gauge shutoff valve must indicate visually whether the valve is open or closed
- **Safety Valves**
 - also known as pop valve or pressure relief valve or relief valve
 - MAWP (Maximum Allowable Working Pressure)
 - relief or regulating valves
 - ASME safety valves
 - proper piping tree for relief and ASME safety valves
 - certified servicing of safety valves and seals
- **Fusible plug**
 - Indicates to the engineer a low water condition
 - must bear ASME stamp on the soft metal
 - must extend at least 1 inch above the crown sheet
 - melts out at 440°F
 - frequency of replacement

2.3.3 Boiler Construction

Parts of a locomotive type boiler

- Firebox, barrel, smoke box
- Side sheets, throat sheet, back head, wagon top
- Firebox parts
 - side sheets, crown sheet back sheet , rear or back tube sheet
 - firebox doors
 - for wood and coal
 - straw chutes and arches
 - OG ring or mud ring
- Barrel
 - uniform diameter barrel
 - some barrels are made with segments of varying diameter
 - smoke box and shell ring
 - first course
 - conical ring
 - dome course (contains the dome)
 - to the throat sheet
 - roof sheet (wagon top)
- Seams and joints
 - riveted boiler
 - lap seam
 - single, double and triple riveted
 - butt strap

- single, double and triple riveted
 - welded
 - strength of joints
- Tensile strength of the boiler sheets
 - sheet thickness and tensile strength
- Front and rear tube sheets (also known as flue sheets)
 - tubes or flues
 - flue size
 - tube sizing measured on outer diameter
 - ferrules
 - rolling
 - beading
 - prossering
- Smoke box
 - purpose of the smoke box
 - components - exhaust pipe, exhaust nozzle or jet, blower pipe, , stack, spark arresters or screens
- Hand hole, gaskets or washout plug
- Stays
 - types and purpose
 - diagonal brace

2.4 Items attached to the boiler

2.4.1. Safety features

- Water gauge glass
- Try cocks
- Safety valve
- Steam Pressure Gauge
- Fusible plug

See 2.3.2

2.4.2. Boiler features

- Devices to put water into the boiler
 - Injectors
 - designed to pickup over a pressure range
 - swing check valves
 - how injectors work
 - how to operate injectors
 - troubleshooting injector problems

- Feed water Pumps
 - mechanical pumps
 - driven by engine motion
 - gear pump
 - eccentric pump
 - crosshead pump
 - move water when engine is turning
 - valves control water flow direction
 - recirculate to tender
 - deliver to boiler
 - independent pumps
 - steam powered pump
 - heaters
 - top check valves
- Nipples and shutoff (isolation) valves off the boiler
 - as opposed to control valves
 - short length Schedule 80 to the first shutoff valve
- Dome Valve
 - what it does
 - when to use it
- Blower
 - what it does
 - caution – chilling tubes with air coming through holes in a fire
- Blow down Valve
 - helps control level of total dissolved minerals
 - planning for a blow down
 - valve design
- Whistle
 - purpose of a whistle
 - whistle codes
 - use around people and animals
 - piping and shutoff valve
- Hand Holes
 - purpose of hand holes
 - installing hand hole gaskets
 - tools required
 - gaskets
 - size varies with different steam traction engines
 - gaskets must be steam service rated (temperature and pressure)

- Ash Pan
 - purpose
 - maintenance
 - not present on wet bottom boilers
- Grates
 - purpose
 - types appropriate to fuel
- Dampers
 - purpose
 - front and rear dampers
 - use of dampers when using arches

2.5 Piping, Fittings and Valves

2.5.1 Pipe

- Types and construction
 - rolled, welded and seamless pipe
 - no galvanized permitted
- Pipe names and sizes
 - pipes are referred to by schedule 40, 80 and 160
 - schedule 40
 - schedule 80
 - SA53 Grade A or B Type E or S
 - designates a pipe fabricated from a strip of steel rolled and welded
 - SA106 Grade A,B or C
 - designates a seamless pipe
- Code requirements:
 - Schedule 80 from the boiler to the first shutoff valve.
 - Schedule 80 seamless pipe and fittings are strongly recommended for use throughout the traction engine piping.

2.5.2 Fittings

- Elbows, nipples, bushings, bell reducers, solid plugs, joiners and unions
 - class for steam service
 - NPT (National Pipe Taper) for boiler fittings.
 - Pipe sealants and Teflon tape

2.5.3 Valves

- globe valve, gate valve and ball valve
- identifying for steam rating

- Check valves
 - swing check
 - top check
 - ball checks (water glass service)
 - where each is best suited
- documentation with purchase of any pipe, fitting or valve

2.6 Boiler Water Treatment

- Purpose of water treatment
 - to control oxygen, minerals and pH
- Boiler water and water tank testing
 - water test kits and labs
 - professional assistance in selection of appropriate chemicals
 - safe storage and handling of treatment chemicals
 - record keeping of test
- Oxygen in water
 - oxygen does its greatest damage in the first 24 hours in a boiler if the water is left untreated and unheated.
 - pitting and necking
 - oxygen scavengers
- Minerals in water
 - scale
 - benefits of sludge creation & control
 - blow down
 - purpose
 - when and considerations for blow down
- pH levels
 - pH10 levels for boilers & water tanks
- Foaming
 - what it is
 - how to deal with it
- Priming
 - what it is
 - how to deal with it

2.7 Engines

2.7.1 Types of Steam Engines

- Simple
 - single
 - double

- Compound
 - tandem
 - cross

2.7.2 Determining Power Output

- the horse power
- drawbar horse power
- torque
- the Prony brake
- dynamometer

2.7.3 Typical Components of Traction Engines

- water tanks and variety of locations
- speed and power controls
 - throttle
 - governor
 - reverse gear
 - reverser quadrant
 - notches for hookup
- engine bed
- crankshaft
- main bearings
- flywheel
- crank disc
- crank pin
- connecting rod
- crosshead
 - crosshead guides
 - crosshead wrist pin
 - crosshead shoes
 - crosshead lubricator
- piston rod
 - valve rod packing
- piston
- cylinder
- valve chest
- valve rod
 - valve rod packing
- eccentrics

- exhaust
- exhaust heater
- clutch
 - clutch lever
 - shoes
 - pin
 - direct (Buffalo Springfield road roller)

2.7.4 Controlling Motion and Power of a Reciprocating Steam Engine

- Throttle
 - controls the amount of steam going to the engine
- Governor
 - what it does
 - normal range of flywheel speed
 - sawyers lever –overriding normal governor setting
 - belts and problems
- Valve and cylinder steam cycle
 - admission, expansion, release, compression
 - cutoff and lead
- Types of valves typically found on traction engines
 - D-valve
 - Gould (balanced)
- Types of valve gear often found on traction engines
 - Woolf
 - Stephenson
 - Marsh
 - Baker
- Setting valve quadrant (forward/reverse)
 - predicting initial motion of crank disk
- Single cylinder dead centres
 - top and bottom dead centres
 - steps to move the flywheel safely off centre
- Hooking up

2.8 Startup Routine Procedures

2.8.1 Crew Preparation For a New Engine

- Water glass in relation to crown sheet
 - Locate the vertical distance between the top of the crown sheet and the top of the bottom nut of the gauge glass. Make a mark with

chalk or paint on the back head of the boiler to show the top of the crown sheet.

- Verify location of try cocks in relation to crown sheet.

2.8.2 Crew Preparation For the Day's Operation

- Standard Items
 - Clothing for operators/engineers and firemen
 - Engineer's log book and/or engineer's license
 - Flashlight, crescent wrench or pliers
- Tools on board the Engine
- Lighting the fire is the last item to do in the list of startup procedures.
- Water checks
 - check water tanks, head tanks, saddle tanks, rear mount tanks, *etc.*
 - prove the water gauge glass (and water column if equipped) when boiler is not under pressure
 - check water level with try cocks
- Boiler integrity
 - check each hand hole for tightness
 - cautions
 - do not over tighten and crush a hand hole gasket. Steam tight is all that is required
 - never adjust a hand hole while the boiler is under pressure or hot. Unintended movement of the hand hole cover or gasket can lead to serious injury.
 - check for leaks: handholds, nipples, fittings valves
- Set all valves and control settings before startup
- Valve operation
 - how to open a valve fully then close by one flat
 - how to close a hot valve and accommodate contraction through cooling
 - how to close a cool valve and accommodate expansion through heating
 - care in opening and admitting hot steam to cold parts of engine (dome valve)
- Cleaning tubes, smoke box, grates and ash pan
- Hot ashes – safe disposal

2.9 Lubrication

- Rule: if there are two moving parts, a joint, a shaft, moving plates then lubrication will be required.

- Types of lubrication
 - Steam cylinder oil
 - Journal or bearing oil
 - grease
- Lubrication delivery
 - oil cups and waste
 - mechanical lubricators
 - hand pump oilers
 - sight glass oilers
 - screw type grease delivery cup (Case crank pin)
 - grease cups
 - grease nipples
 - hydrostatic lubricator
- Checking Bearings
 - dry or tight bearings heat up
 - back of hand
 - infrared thermometer

2.10 Firing

- Starting with clean tubes, clean ash pan and clean grates
- Fire slowly and gently to heat castings
- Types of fuels
 - wood
 - coal
 - straw
 - oil
- Condensation on a cold boiler firing in the morning appears like leaking tubes
- Holes in a fire
- Grates
 - hold the fire so that air can move up through the fuel.
 - grate air spaces are designed with different fuels in mind.
- Arches
 - purpose of arches
 - types – brick arches and metal arches
- Draft
 - types of draft
 - management for boilers with arches
 - draft regulation and air restriction
 - front dampers and rear dampers

- when and how to use
- back draft
 - causes
 - hazard
- Banking
 - how to
 - how advisable
- Letting a fire die effectively and safely

2.11 Handling an Engine

- routinely checking water in water tank(s)
- proving a water gauge glass under pressure (NBIC Procedure)
- use of try cocks
 - color & sound of discharge
 - how to use the try cock to get the most accurate reading
- use of cylinder drain cocks
- use of clutch and pins
- throttle control initially and moving
- hooking up reverse lever
- normal stopping
 - close throttle, open cylinder drain cocks, set reverse lever to neutral (valve quadrant) and disengage clutch (if engaged)
- braking without brakes
 - gradual downhill speed control with low fire,
 - damper closed,
 - use reverse lever and a little throttle
- steering
 - with a chain
 - power steering (which reverses when you reverse)
- operating on belt with governor speed
 - starting, running and stopping without losing the belt

2.12 Belting up, Hitching and Maneuvering

- how to maneuver and position appropriately
- how to belt up
 - crew duties while belting up
- crew duties while operating on the belt
- connecting to pull equipment with a steam traction engine
- maneuvering close to objects
 - parading

- parking

2.13 Emergency Procedures:

- How to isolate the boiler from the engine:
- Control settings to stop the steam traction engine
- How to kill a fire safely and quickly
- Situations and actions to take
 - water glass breaks
 - runaway engine and governor over speed
 - injector trouble
 - foaming or priming
 - hand hole gasket blows out
 - tube or flue bursts
 - leaking valve
 - broken pipe
 - safety valve problems
 - not opening at set pressure
 - opens but won't close
 - leaking pipe plugs
 - melted grates
 - thrown drive belt

2.14 Shutdown

- End of day shutdown (not a lay-up)
 - Blow down procedure
 - positions of valves and controls
- When is it safe to leave an engine?
 - steam traction engine is blocked to prevent rolling
 - water glass is 2/3 full
 - dome valve is closed
 - feed water shutoff valves are closed
 - steam shutoff to injectors and/or steam water pump
 - dampers closed and fire is dying
 - steam pressure is 20 psi below relief valve pressure setting
 - steam pressure is going down
- Short term boiler lay-up tasks
- Long term boiler lay-up tasks
 - Boiler washing procedure
 - Screens and wicking
 - Special considerations involving freezing conditions

2.15 Inspection

- Types of test and preparation
 - Visual/internal inspection
 - Hydrostatic testing
 - water temperature
 - pressure level
 - Non Destructive Examinations
 - Operational (under pressure) examination
- Frequency of inspections
- Preparations for inspection
- Determination of maximum allowable working pressure (MAWP)

2.16 Repairs and Modifications

- SAM QA program
- Repair plans
- Approval process
- Certification of service providers
- Pre- and post-repair inspection

2.17 Log Books

- personal logbook of operation experience
- engine log of operation and maintenance

2.18 Boiler Law and Regulations

- ASME American Society of Mechanical Engineers
 - what ASME regulates
- NBIC National Boiler Inspection Code
 - NBIC Parts 2 & 3 Sections 6 relating to inspection and repair of Historic Boilers
- CSA Canadian Standards Association
 - what CSA regulates
- Manitoba Provincial Pressure Vessel Act and Regulations
- Office of the Fire Commissioner, Inspection and Technical Services Manitoba

3. History of Steam Traction Engine Development (optional)

- major technical developments
- influence of “the Alberta or Canadian Boiler”
- companies and mergers
- interesting features that worked/failed to work

4. Summary of changes

- Safety features appearing redundantly in 2.4 were merged into 2.3.2.
- 2.4 Items attached to the boiler was subdivide into 2.4.1 Safety features, which contains a short list as a placeholder and a reference to 2.3.2, and 2.4.2 Boiler features, which contains the remainder of the items.
- Redundant fusible plug references were merged into 2.3.2.