Passenger Car 1213 Air Conditioning Retrofit and Update

Summer 2026

Minnesota Transportation Museum

St. Paul, Minnesota USA

Written by: Bryan Heinle August 2026

Purpose of document:

Describe and document the process of converting the mechanical refrigeration aspect of the air conditioning system in passenger car 1213. With this document, it should be “reasonably easy” to recreate this project on future cars. The document attempts to capture the decisions made and the work done during the conversion process. Many photos and written descriptions document the work. Throughout the document, information panels list the exact parts used. The document will conclude with the lessons learned and things we may do differently next time.

Not everything got done. The project was done by volunteers during a busy summer season. As with all projects, unexpected work and delays materialized. In the end, work had to be prioritized to meet the schedule and deadline. Some smaller details may have to be completed when the car returns to the shop over the winter months. Larger desired details will have to wait for future funding opportunities.

This project is the first of several cars to be converted. This project defines the recipe for the future projects. Some of the “potential” future conversion projects can be seen in the Forward section.

Whereas this document will lightly discuss the electrical control system used by the air conditioning system, the power generation and distribution system received a major upgrade. The details of that portion of the project will be covered in a different document.

By design, this document does not directly cover cost. As noted later in the Forward section, this project had boundaries defined by funding.

Project Goals:

Improve the customer experience by upgrading the air conditioning system in the car. This will be accomplished by doing the following:

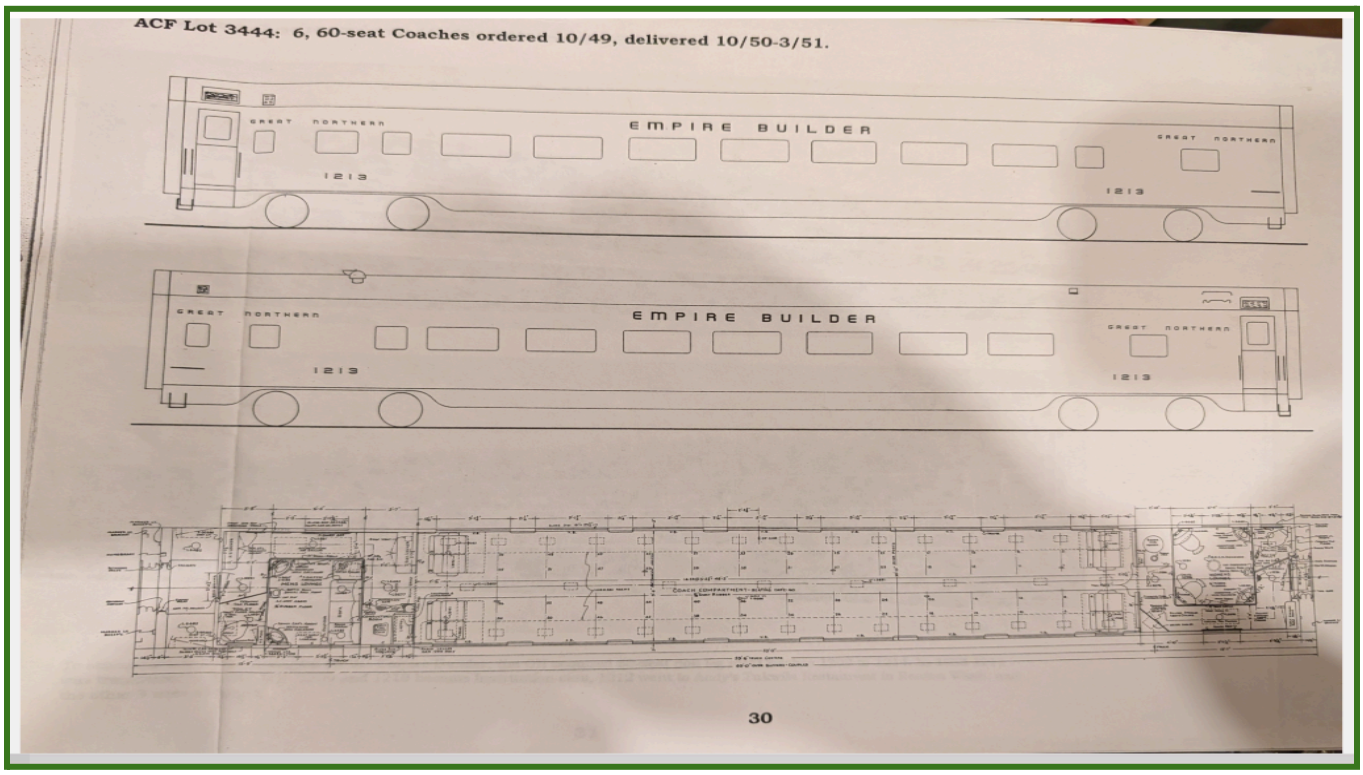
- Build an air conditioning system which is leak free
- Build an air conditioning system which is mechanically reliable
- Build an air conditioning system which will operate in an automatic mode
- Build an air conditioning system which will be significantly easier to maintain
- Build an air conditioning system which will be less expensive to maintain
- Build an air conditioning system which uses modern refrigerants and oils
- Establish a pattern for future conversions by this museum, or others

Passenger Car Information:

Car 1213 was operated by the Great Northern Railroad on the Empire Builder route. The 60 passenger car was delivered in March of 1951. The car was manufactured by AC&F (American Car and Foundry).

The car is often referred to as car GN1213 throughout this document.

Photo #1: Original drawing from ACF. Note: 6 cars ordered in October 1949



Car 1213 has roughly 740 square feet of conditioned space. It is believed the cooling coil is 8 tons. Thus the original design had approximately 92.5 square feet per ton of air conditioning. This is very much in line with air conditioning sizing for commercial multi use space.

Car 1213 was out of service throughout the Summer of 2026. The Museum set a goal of the car being returned to customer service on theOsceola & St. Croix Valley Railway in mid September, 2026.

Photo #2: Car 1213 on its spring migration to Osceola, Wisconsin - May 2025



In photo #2, the electric compressor unit can be seen mounted close to the center of the car.

Forward:

The Minnesota Transportation Museum has a mixed fleet of 1910's, 1920's and 1950's passenger cars used for an excursion railway in Osceola Wisconsin. The cars are currently equipped with a mixture of original Waukesha ICE engines, Onan diesel generators, and a original Waukesha Enginator 32 Volt DC generator. The cars are equipped with the original 32-Volt DC train line, currently used to interconnect cars. The retrofitted Onan diesel generators are 220v split-phase of varying capacity. In-car power is a mixture of 220v single phase, 120vac and 32v DC. In generator-equipped cars, 32v DC is supplied by a mixture of transformer/rectifiers and DC power supplies. None of the cars had 32v batteries installed.

The organization had decided that any future electrical upgrades would be consistent with Amtrak Quarter HEP, I.E. 480v-3phase, that Quarter HEP would be used to interconnect the cars, that any cars require any power other than 480-3phase would transform that into whatever needed in each car, and that the 32V train line would eventually be abandoned - leaving only the Amtrak HEP connections between cars. This 'standard' was documented and published.

The Organization desires to complete one car per year if funding and volunteer resources are available.

For this project, constrained by both budget and timeline, the organization decided that the actual implementation of the Amtrak inter-car connections could be deferred until a later phase in the project.

At the start of this project, GN1213 was equipped with an Onan generator, an OEM A/C compressor driven by a 220v single-phase motor, an OEM sub-cooler, and a 32v battery charger supplying 32vdc for car lighting and trainline. At some point in the past, the OEM 32v DC evaporator fan motor had been replaced by a single 3/4hp 120v motor driving both fans. The existing fan cages and fans were in good condition. The motor was believed to be overloaded.

Prior to starting work on GN-1213's the generator and condenser/compressor unit upgrades, the existing compressor/condenser unit, sub-cooler, refrigeration lines and Onan generator were removed, asbestos abatement was conducted, and most of the original steam and refrigeration lines were removed.

The organization had a new NorthWest Rail Electric 240V compressor/condenser originally intended for another project and decided to repurpose that unit rather than purchasing a new condenser/compressor. A transformer was used to provide required power to the condenser/compressor unit. The organization purchased a new Stadco 42 KVA generator to replace the existing decades-old Onan generator.

The existing evaporator was cleaned and leak-tested. Refrigeration valves were replaced with ones compatible with the new condenser/compressor unit. The evaporator fans were reinstalled using the original fan housing and fans, with new 3/4hp 240 Volt AC PSC motors powering each fan. Fan RPM and motor size were based on industry-standard calculations made by qualified volunteers.

New mounts were fabricated for the 42kva generator and NW Rail condenser/compressor unit. Both were mounted in or near the original locations. When mounting the units, consideration was given to Amtrak clearance requirements. In the case of the generator, we were able to reuse the existing generator mounting pads but were unable to completely meet Amtrak clearance requirements. For use as passenger cars on the Osceola Scenic Railway this was considered acceptable.

The original diesel fuel tank was removed, cleaned and reinstalled.

To clear space for 480V and 220V panels, most of the original 32V DC electrical equipment was removed. A 32v DC power supply was installed to power the existing low-voltage DC lighting. A 480/220 transformer was installed under the car. Existing electrical cabinets, under-floor raceways and under-car conduit were reused whenever possible.

Photo #3: Waukesha Ice engine and subcooler on historic car A11



Photo #4: 32 VDC refrigeration compressor on car MNTX 1224



Photo #5: Upgraded compressor motor drive on car 1215



Minnesota Transportation Museum (MTM) Team:

Rob Meyer
Bob Puelston
Kurt Mahre
Mike Janke
Steve Hansen
Terry Phinney
Paul Scheunemann
Tim Nelson
Tim Grube
Hank Harp
Wayne Torseth
Richard Kasseth
Bob Clark
Bryan Heinle

About Minnesota Transportation Museum (MTM):

office@trainride.org

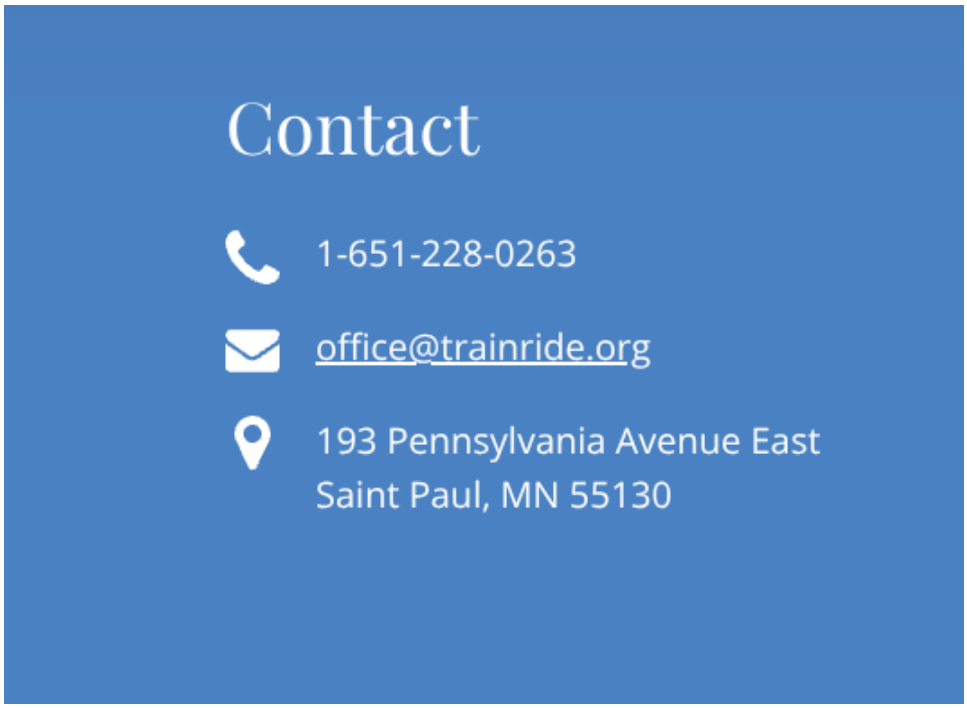


Table of Contents:

Purpose of document: **2**
Project Goals: **2**
Passenger Car Information: **3**
Photo #1: Original drawing from ACF. Note: 6 cars ordered in October 1949 3
Photo #2: Car 1213 on its spring migration to Osceola, Wisconsin - May 2025 4
Forward: **5**
Photo #3: Waukesha Ice engine and subcooler on historic car A11 6
Photo #4: 32 VDC refrigeration compressor on car MNTX 1224 7
Photo #5: Upgraded compressor motor drive on car 1215 7
Minnesota Transportation Museum (MTM) Team: **8**
About Minnesota Transportation Museum (MTM): **8**
The Existing Air Conditioning System and Components: **11**
Condensing Unit: 11
Photo #6: Example of a 32 VDC refrigeration compressor (from MNTX 1224) 11
Evaporator Coil, Steam Coil and Refrigeration Control Valves: 11
Information Panel #1: Information on evaporator and TXVs 12
Photo #7: Original R-12 Frigidaire Thermostatic Expansion Valve (TXV) 13
Photo #8: Original evaporator coil information with Serial number and Mfg date 13
Photo #9: Original evaporator coil information (Frigidaire Corp) 14
Photo #10: Original expansion valve and solenoid valve assembly 15
Photo #11: Original refrigerant distributor (will be reused) 16
Evaporator Fan Motor, Blower Wheels and Fan Housings: 16
Photo #12: Original fan blower wheel size 17
Refrigeration Piping and Insulation: 17
CAUTION: Asbestos 17
The Replacement Air Conditioning System and Components: **19**
Power Generation System and Supply: 19
Photo #13: Stadco generator being installed 19
Condensing Unit: 20
Information Panel #2: Information on Northwest Rail Electric Inc. 21
Photo #14: Exact Northwest Rail Electric Inc. model numbers 21
Photo #15: Northwest Rail Electric condensing unit installed, piped and being wired 22
Information Panel #3: Model numbers from Northwest Rail Electric Inc. 22
Information Panel #4: Piping sizes from the Northwest Rail Electric Inc. condenser 22
Photo #16: Side view of car 1213 showing condensing unit. Note: Diesel tank is not in place. 23
Refrigeration Piping and Insulation: 23
Photo #17: Soft soldered stubs on evaporator (1950) 24
Photo #18: Brazed pipes under the car ready for final insulation. Bracketing shown. 25
Refrigeration Valves and Components: 26
Information Panel #5: Refrigeration valves and components used 26
Photo #19: Sporlan TXV used (x2) 27

Photo #20: Detail of upper TXV flare joint and copper clamp on original bracket 27
Photo #21: Refrigeration heat exchanger being installed in the pipe chase 28
Photo #22: Solenoid valve installed on the original bracket 29
Photo #23: Expansion valves installed on the original brackets 29
Photo #24: Expansion valves with flared outlet installed on the original brackets 30
Evaporator Coil and Refrigerant Distributor: 30
Refrigerant and Oil: 30
Fan Motors, Blower Wheels and Fan Housing Assemblies: 31
Photo #25: Aluminum reinforcement panel installed on aluminum fan housing 31
Photo #26: Belly mounted, frame 48, ¾ HP fan motors of PSC design. 32
Information Panel #6: Lau squirrel cage fan wheels used 32
Photo #27: Both fan motors installed but not yet wired permanently. Note: Ease of service. 33
Diagram #1: Lau engineering data for Model DD9-9A fan wheels 34
Diagram #2: Lau DD9-9A information specific to car 1213 and the desired 1,600 cfm 35
Photo #28: Fan motor used (x2) 36
Photo #29: Close up of evaporator fan installation and belly mount bracket 37
Electrical Controls: 38
Photo #30: Northwest Rail Electric SS1 “ON” position for “Automatic” operation 38
Lessons Learned During System Installation and Startup: 39
Evaporator Fans: 39
Refrigeration System: 40
Photo #31: Distributors showing even feeding (even condensation) 41
Refrigeration Piping: 42
Final Thoughts for the Full Airflow of 1,600 cfm: 43
Duration of Project: 43
How the goals can be measured: 44

The Existing Air Conditioning System and Components:

At the time of the project (Summer 2026), car 1213 had the following equipment installed. Most of the equipment will be replaced; however, some will move forward with the project.

Condensing Unit:

The original condensing unit was a DC electric motor driving an open drive refrigeration compressor. The original refrigerant was R-12. The condensing unit in the car at the time of this retrofit was powered by an 32 Volt DC motor. The power was provided by an on-board battery charger. The compressor was an open-shaft Trane reciprocating unit. The condensing unit also had an original water subcooler unit which was in service. This subcooler was enormous and had to be manually refilled often.
The compressor shaft seal was no longer reliable and was difficult to service. The risk of unacceptable refrigerant loss was too great. The refrigerant in use was R-134A with POE oil.
This unit was completely removed and will not be reused. A close-up picture of car 1213 with the original compressor was not readily available. However, car MNTX 1224 is very similar. Also, see photo #2.

Photo #6: Example of a 32 VDC refrigeration compressor (from MNTX 1224)



Evaporator Coil, Steam Coil and Refrigeration Control Valves:

The evaporator is physically located above the ceiling in the men's room on the vestibule end. The coil is believed to be an 8 ton cooling capacity coil. The coil is of draw-through design complete with a condensate drain pan. This coil has two independent circuits of equal capacity (believed to be 4 tons each). The coil is face split. Each circuit is fed by a Thermostatic Expansion Valve (TXV) and a refrigerant distributor. The TXV

valves and distributor were designed for R-12 service. The 2nd circuit was controlled On / Off by a refrigeration solenoid valve. In this way, two stages of cooling was possible.
The coil was in excellent condition The coil itself, complete with refrigerant distributors, will remain in service and move forward with the project. Naturally, the expansion valves will be replaced. It is noted early on that the residual POE oil will have to be flushed clean.

Information Panel #1: Information on evaporator and TXVs

- Coil manufacturer and Serial Number: Frigidaire 3890 Mfg July, 1950
- TXV information: Frigidaire Modulex F-12 MX49ECC (x2)
- Refrigerant distributor information: Little is known. It's a 4 circuit distributor with ¼" OD tubes of about 9" in length.

A steam / hot water coil is situated at the air leaving outlet of the air conditioning coil. This coil is no longer being used. There is discussion about a future replacement and upgrade of this coil to an electric resistance coil.

It is noted that the presence of this steam / hot water coil causes some system performance concern. The coil is a source of air pressure drop. Since the coil serves no useful purpose at this time, the pressure drop is constantly felt by the fan and has a constant negative effect on fan performance. Best practice would be to remove this coil.

As part of the project, the coils were properly cleaned with high pressure water and a coil cleaning solution. The drain pan and condensate line are both in good condition. The evaporator coil was successfully pressure tested with all the original components very early in the project. This was done to gain confidence with the coil.

All the refrigeration control valves and components will be replaced with Sporlan (Parker Hannifin Corporation) products.

The coil had some kind of silver coating on all the copper pipes and metal end panels. It's unclear what the coating is (was). Whatever it is, it sure worked well, did it's job and withstood the test of time. None of this silver coating was disturbed or removed.

Photo #7: Original R-12 Frigidaire Thermostatic Expansion Valve (TXV)



Photo #8: Original evaporator coil information with Serial number and Mfg date



Photo #9: Original evaporator coil information (Frigidaire Corp)

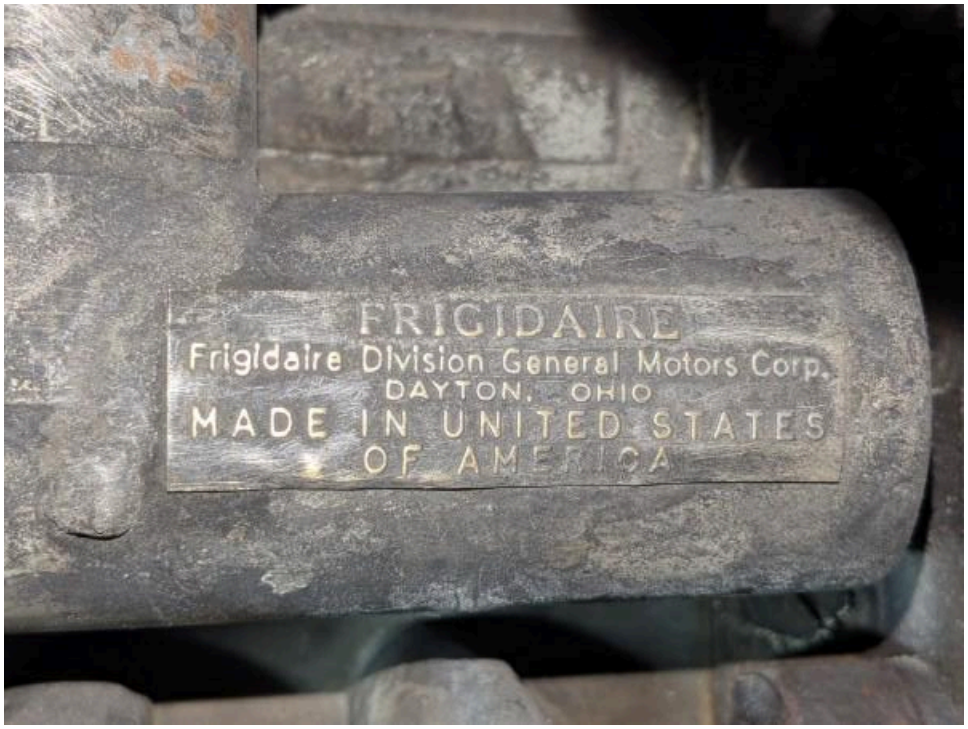


Photo #10: Original expansion valve and solenoid valve assembly

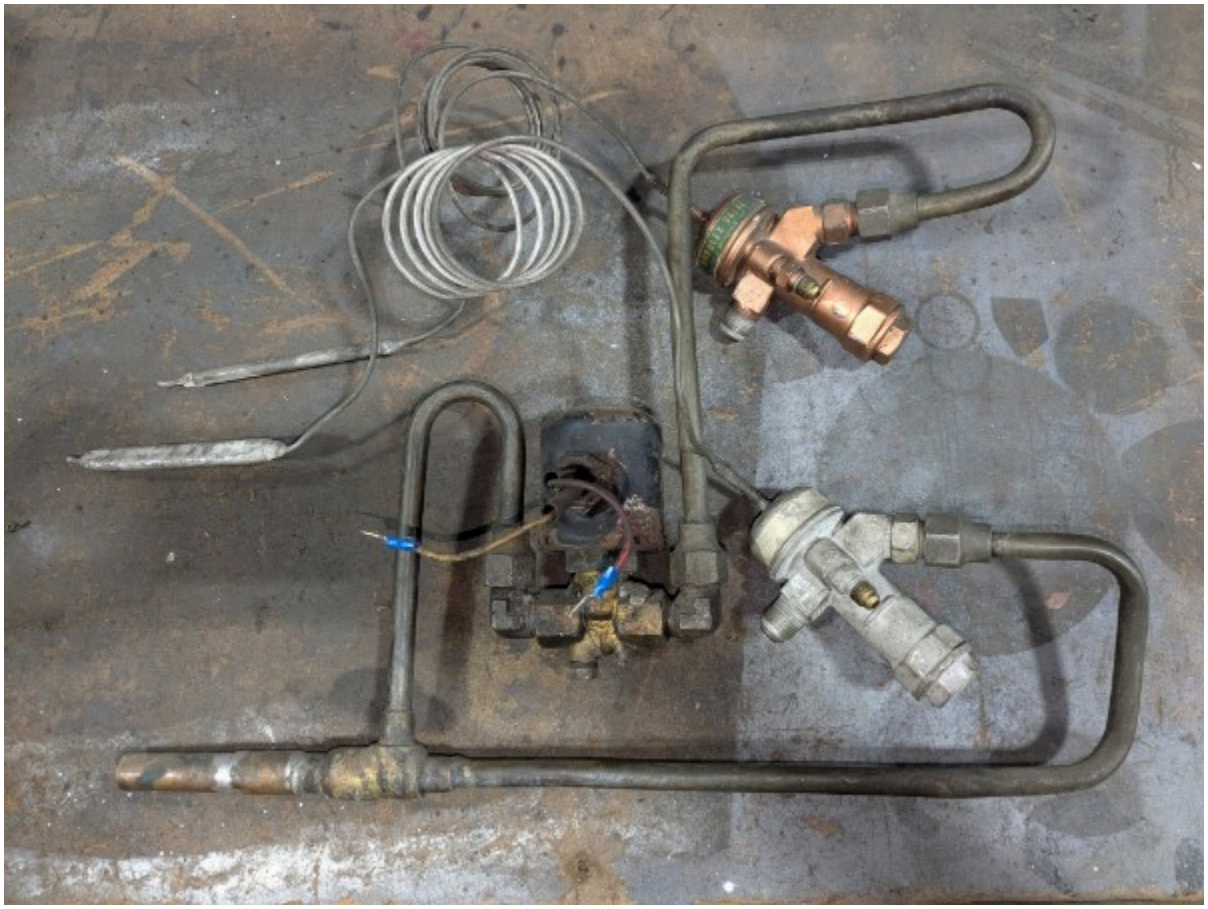


Photo #11: Original refrigerant distributor (will be reused)



Evaporator Fan Motor, Blower Wheels and Fan Housings:

The original fan motor was a single 32 Volt DC motor with dual shafts. The motor had a speed of 1120 rpm. Each shaft turned a blower wheel. There are two blower housings. Each blower housing contributes half of the total air flow for the system.

The fan housings are of aluminum construction and can be split for service.

At the time of the project, the original 32 Volt motor and original blower wheels had long since been replaced. The replacement motor was a single 110 Volt AC motor with dual shafts. This motor was ¾ HP at 1075 rpm. This motor was probably OK for emergency service but was not adequate for permanent operation.

The ¾ HP motor was underpowered and will not be reused. The dual shaft motor also had shaft extensions of 4 inches on each shaft. This design caused considerable wobble and vibration. A far better solution will be designed and implemented.

The original fan blower wheel dimensions were 10 x 9. This was known by a stamping on the fan housing. The original fan blower wheels are not known to exist.

The fan blower wheels are replacement Lau 9 x 9 wheels (one CW and one CCW). The Lau 9 x 9 fan blower wheels appear to be a good choice and will move forward with the project and be reused. It is noted that Lau also makes a 10 x 9 blower wheel. However, there just is no time to experiment with different wheels. The wheels which the museum already owns will be used. In part, to help contain cost.

The aluminum fan housings are in good condition and will be reused. The housings were removed and properly cleaned. However, it will later be discussed that reinforcement of the housings will be necessary to support the addition of belly bands.

Photo #12: Original fan blower wheel size



Refrigeration Piping and Insulation:

CAUTION: Asbestos

The original pipe was covered with asbestos insulation. Also, the pipe brackets had asbestos padding.

Each of the two outlets on the evaporator coil are 1-⅝" OD copper. These two outlets were connected to a 2-⅛" tee. The 2-⅛" copper was type K. The 2-⅛" suction line ran to the condensing unit. The pipe inside the car was wrapped with asbestos insulation. The pipe outside the car was uninsulated. All joints were soft soldered with Stay-Brite type solder. The liquid line was ¾" OD type K copper.

The refrigeration piping was leak free. A testimonial to the fact that type K copper was used and the outstanding durability of Stay-Brite solder. The original craftsmanship was impressive! However, the condition of the exposed exterior copper and pipe supports was poor due to corrosion. For this reason, all the refrigeration copper was removed and will be replaced.

A suction line heat exchanger was installed at the evaporator outlet. The heat exchanger was very large and was physically situated immediately below the roof deck. This heat exchanger was incredibly robust in design!

This heat exchanger will not be reused. A new heat exchanger, of more modern design, will be installed in the pipe chase.

IMPORTANT NOTE: The two outlet stubs on the evaporator coil are soft soldered to the header with Stay-Brite solder. This is important as these two stubs are reused. Therefore, these stubs have to be handled very carefully as to not crack the soldered connection! Also, soldering these stubs to the new piping will be very tricky! Precise control of the torch heat and flame will be necessary.

The Replacement Air Conditioning System and Components:

This section describes the replacement components and the engineering which went into the selection.

Power Generation System and Supply:

A new Stadco 42 KVA generator has been installed on the car to provide all electrical power. This is a diesel powered generator. The existing diesel tank already installed on the car will be flushed and used.
A transformer will be used to convert 480 Volt power from the generator to 240 Volt required by the condensing unit.

It is not possible to run the Air Conditioning system when the Stadco generator is not running. The generator must also be running to run the evaporator fans for air circulation.

A dedicated document will be created for the electrical system(s) of car 1213.

Photo #13: Stadco generator being installed



Condensing Unit:

A high quality condensing unit from Northwest Rail Electric Inc.was chosen. The unit is 240 Volt, 3 phase, 60 cycles. The unit is designed to use refrigerant R-422B. This unit was suspended under the car in the location occupied by the original condensing unit.

It should be noted that this unit was initially intended for another project. MTM purchased this condensing unit as New Old Stock. This is why there is a mismatch in Voltage. A decision was made by the Museum volunteer team to transform the Voltage as opposed to converting the condensing unit to 480 Volt operation. This was a difficult decision with several details which received careful consideration.

It must also be noted that the condensing unit has a Carlyle compressor with the following model number: O6DA328SD13250. This is a 28 cfm compressor with a 27 LBFT motor (9.25 HP). This does not match the 8 ton coil very well and could possibly be an issue. The compressor is oversized for the evaporator. I estimate 20%. Fortunately, the condensing unit has a hot gas bypass capacity control apparatus installed. That will be very important later. This compressor does not have any capacity control unloaders installed. However, as noted later in the document, the evaporator coil will also have “slightly” greater capacity with R-422B. The only way to know exactly where the balance will be is to run the unit.

An optional 120 Volt, 180 Watt stick-on crankcase heater was attached to the underneath of the compressor (on the metal crankcase cover). This is necessary as the car will standby all week without power. The maintenance team will plug this crankcase heater into shore power while the car is standing by. When the car is powered by its own generator, the crankcase heater installed by the manufacturer will resume normal operation. By doing this, the AC system will be able to be immediately started up when the car is made ready for operation. If the maintenance team forgets to plug in the heater, 180 Watts is sufficient to allow a startup after 1 hour. Best practice will be to leave the optional 120 Volt heater on the entire time the car is standing by.

Information Panel #2: Information on Northwest Rail Electric Inc.



Photo #14: Exact Northwest Rail Electric Inc. model numbers

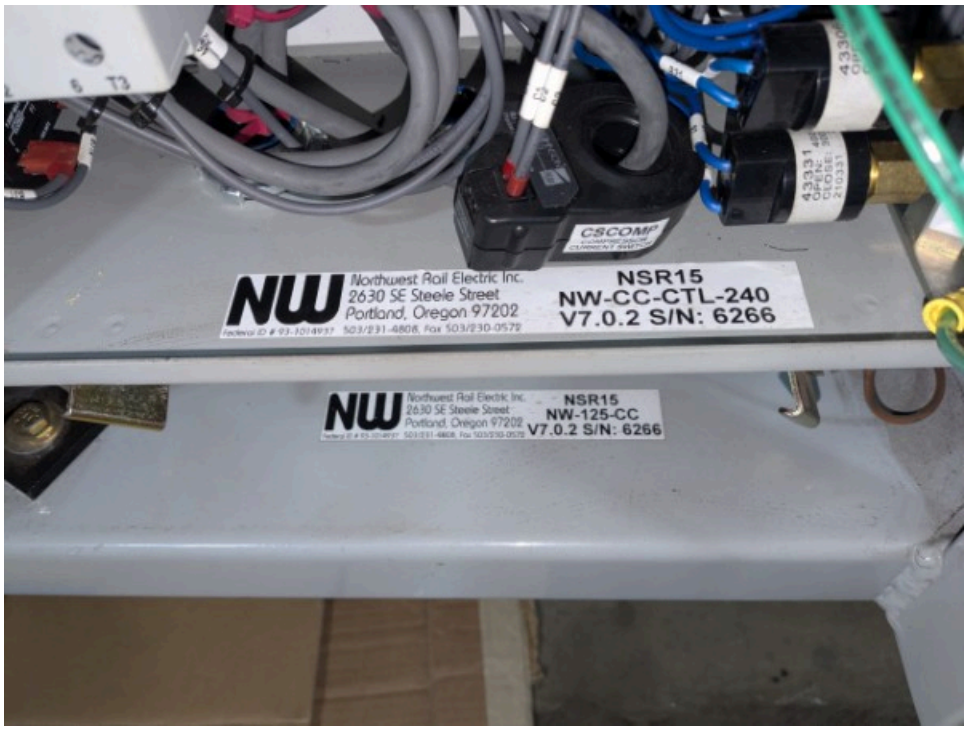
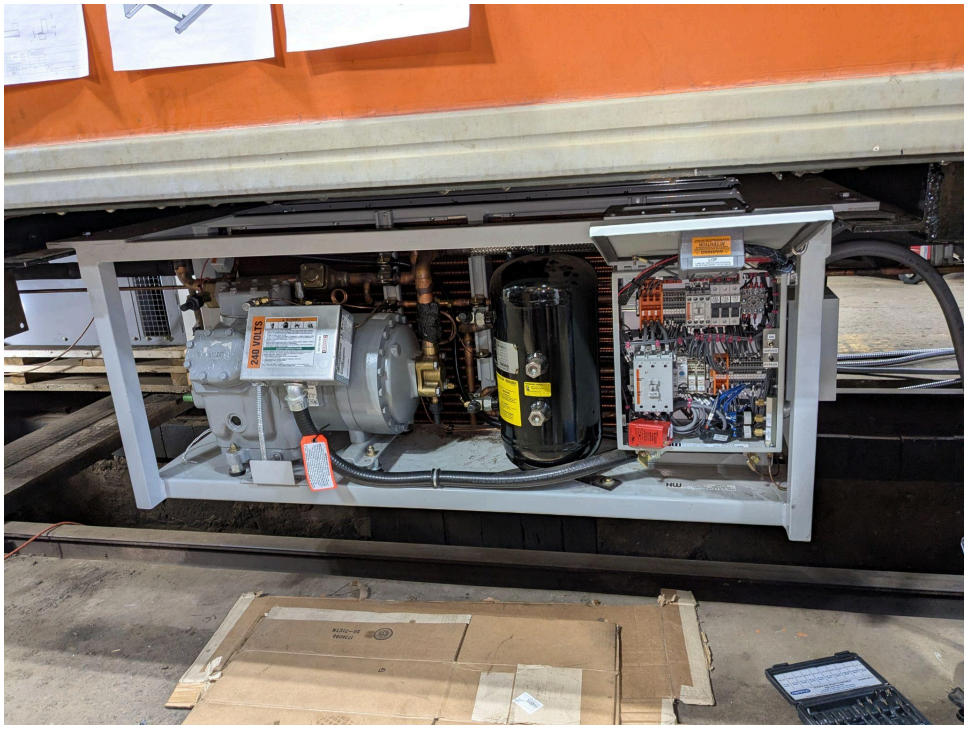


Photo #15: Northwest Rail Electric condensing unit installed, piped and being wired



Information Panel #3: Model numbers from Northwest Rail Electric Inc.

Condensing Unit:	NW-125-CC	V7.0.2	Serial Number 6266
Control Panel:	NW-CC-CTL-240	V7.0.2	Serial Number 6266
Wiring Diagram:	NW-125-CC	V7.0.2	240VAC Cond Unit

Information Panel #4: Piping sizes from the Northwest Rail Electric Inc. condenser

The Northwest Rail Electric condensing unit had the following pipe sizes. This worked well with R-422B

Suction line:	1-⅜”
Discharge line:	1-⅛”
Liquid line	⅝”

The purpose of recording line sizes is if a unit intended for R-410A is utilized, but an attempt to converted it to R-422B is made. In that case, proper line sizing will be critical.

Photo #16: Side view of car 1213 showing condensing unit. Note: Diesel tank is not in place.



Refrigeration Piping and Insulation:

Type L HVAC/R copper was used. The condensing unit came with a 1-⅜” OD suction connection and a ⅝” OD liquid connection. The evaporator has two 1-⅝” stubs. The evaporator connections were connected to an 1-⅝” tee. The 1-⅝” line ran to the underneath of the car (above the truk). From that point on, 1-⅜” OD tube was run to the condensing unit. All suction line tubing above the floor was 1-⅝”.

A 1-⅝” suction line heat exchanger was installed. Room for this heat exchanger was found in the pipe chase.

All liquid line piping was ⅝” OD. This includes the liquid line solenoid valve. After the liquid line solenoid valve, the liquid line comes to a tee fitting and feeds both of the expansion valves.

All joints were brazed with 5% Sil-Fos brazing alloy. With the exception of two critical joints noted below.

Great care must be taken with the two outlet stubs on the evaporator coil. They are attached to the header with Stay-Brite soft solder. For that reason, the fittings on the stubs were also soft soldered with Stay-Brite and

Stay-Clean flux. Because the stubs are only about 6 inches long, it was not deemed reasonable to weld on the stub with the Sil-Fos 5% brazing rod.

Photo #17: Soft soldered stubs on evaporator (1950)



The liquid lines on the evaporator (outlet of the expansion valves) were ½" flare. Again, it was not deemed reasonable to change these flare connections to a brazed joint. For that reason, the expansion valves were fitted with a ½" male flare fittings and the existing flare nuts and flare connections were successfully used. To make this ½" male flare fitting adapter, Silver Solder was used on the brass.

Because the evaporator contained soft soldered joints and flare fittings, the evaporator, and all interconnecting piping above the truck, was successfully pressure tested for a 4 week period. This was done to gain full confidence in the leak tight integrity of the high risk areas of the refrigeration system.

The suction line was insulated with ½" closed cell pipe insulation. The liquid line from the outlet of the heat exchanger all the way to the expansion valves was insulated with ½" closed cell pipe insulation. The liquid line from the condensing unit to the heat exchanger was not insulated.

The refrigeration lines were run in the existing pipe chase openings above the truck. This keeps the pipes neatly out of the way of the truck. Getting a full length of 1-⅜" OD copper into that chase way was difficult, but possible. In that chase area above the truk, the existing pipe clamp mechanisms (which were wrapped with asbestos) were modified to a more modern vibration eliminating clamps. After the truk, the suction line was

dropped down and Unistrut pipe supports with vibration eliminating clamps were used. It was not reasonable to stay in the existing pipe chase after the truk because of the existence of a field-installed septic tank. Thus, the pipes dropped down and went around the tank and to the condensing unit. Looking back, it may have been better to do the work and drop the septic tank and keep the piping in the existing pipe chase.

The brazing above the ceiling of car 1213, and immediately below the floor, was tricky and had to be done with extreme caution. 1-⅝" piping requires a great deal of heat with an oxy-aceteylene torch. Brazing was safely done with a three person team. One person doing the actual welding while two people stood by with fire fighting equipment (extinguisher and water hose). A fire blanket was spread out over the ceiling as best as possible. A firewatch period was observed after the final brazing operation. The suction piping header was pre-fit and bench welded as much as possible. Only the final joints were actually brazed above the ceiling.

Photo #18: Brazed pipes under the car ready for final insulation. Bracketing shown.



The transition from 1-⅝" OD copper to 1-⅜" was done at the elbow below the floor. This can be seen in the above photo.

Refrigeration Valves and Components:

The following components were used:

Information Panel #5: Refrigeration valves and components used

- Packless Industries HXR-350A 1-⅝ suction line heat exchanger
- Sporlan C-305-S liquid line filter / drier
- Sporlan SA-15S sight glass
- Sporlan E10S250 solenoid Valve
- Sporlan MKC-2 solenoid coil
- Sporlan EBFVE-C-C balanced port expansion valves (x2)
    - Sporlan Item Number: 109073
        - Note: 110123 valves were specified, but not delivered (EBFVE-C-CP100).

A lot of engineering effort and careful consideration was put into the selection of the expansion valves! It is the TXV valves that will determine the system's personality and make the bridge between the 1950 evaporator coil and the modern condensing unit. The TXV valves are a very key component in the operation of the system. The TXV valves are perhaps the single most important component of the system.

These valves are R-22 and will run on R-422B. There is no hesitation in doing this. Experts familiar with Sporlan valves approved this.

These EBF Sporlan valves are balanced port. Expansion valves with a balanced port design are absolutely necessary in this application with mismatched equipment. Early on, a decision was made to go with two expansion valves as opposed to using a single larger valve and piping the two evaporator circuits together. These valves have a size C cage and are good for 3-¼ - 5-½ tons. It is believed that each circuit is 4 tons.

These valves have a C power assembly charge. A VP-100 charge was desired, but not delivered by the refrigeration wholesaler. The C charge is OK, but intended more so for commercial temperature refrigeration. The C charge will not throttle back and limit pressure during a high temperature startup. This may, or may not, be an issue. Typically, expansion valves used in air conditioning applications have a pressure limiting design which is called VP. A VP-100 charged power assembly will not let the suction pressure rise above 100 psi during start up. Now, in the case of car 1213, the condensing unit is generously oversized. The condensing unit most likely will not be overloaded during pulldown. Nevertheless, the desire for VP pressure limiting valves still exists. It is unclear why the refrigeration wholesaler could not deliver the requested valves.

Photo #19: Sporlan TXV used (x2)



As noted earlier, the expansion valves are female sweat with extended stubs. It was desired to reuse the original ½" flare connections on the evaporator. Thus, a brass flare fitting was adapted to the outlet of the expansion valve and soldered with Silver Solder. By doing that, only one flare joint was left, per system, on the evaporator. The ¼" external equalizer line was brazed and the existing flare connection was eliminated.

Note: This brass fitting has a high pressure drop. This fitting design will be improved next time. This is covered later in the document. The idea will go forward. But, this particular design will not.

Photo #20: Detail of upper TXV flare joint and copper clamp on original bracket



The solenoid valve and both expansion valves were supported by the original brackets on the evaporator coil. Custom copper mounting hardware of simple design was made.

To account for the additional heat added to the suction gas by the heat exchanger, which is downstream of the expansion valve temperature bulbs; the expansion valve adjustment stems were opened one full turn prior to installation.

Photo #21: Refrigeration heat exchanger being installed in the pipe chase



Photo #22: Solenoid valve installed on the original bracket



Photo #23: Expansion valves installed on the original brackets

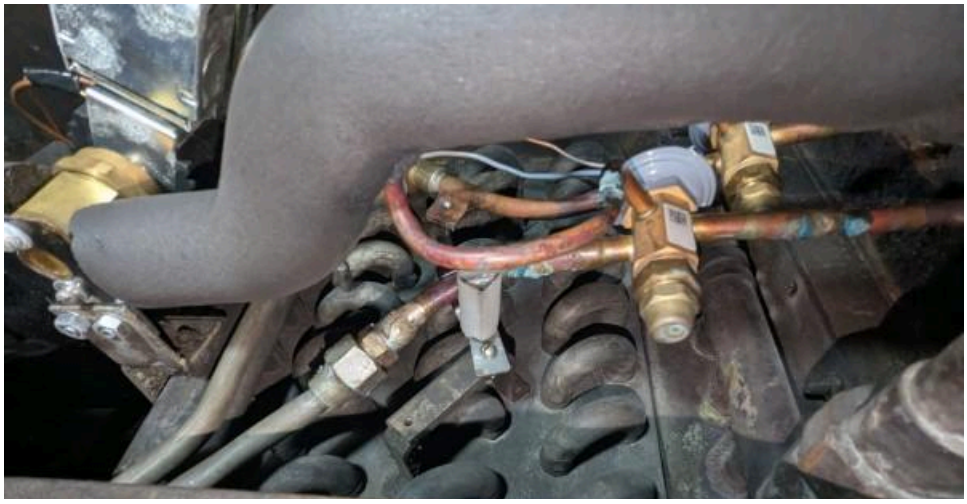


Photo #24: Expansion valves with flared outlet installed on the original brackets



Evaporator Coil and Refrigerant Distributor:

The original coil and refrigerant distributors will be used as is.
There was some engineering work done to estimate how the R-12 refrigerant distributors would work with R-422B. Several experts agreed that the distributors should be functional. It is suspected that they are slightly oversized for refrigerant R-422B. It's not felt that this will be an issue.

Important Note: It must be mentioned that the cooling capacity of the AC coil will be different with R-422B as opposed to R-12. It is reasonable to assume that the coil will now have a greater cooling capacity. However, no engineering data is available to determine how much more. This increase is due to the difference in Latent Heat capacity of the two refrigerants. The Latent Heat capacity of R-12 is approximately 71 Btu/lb; whereas, R-422B is approximately 84.2 Btu/lb. This works in favor of the project as the condensing unit has excess capacity!

Refrigerant and Oil:

Refrigerant R-422B will be used in place of R-22.
Nu-Calgon Zerol 150 oil came from Northwest Rail already installed in the Carlyle O6D compressor and will be used. Zerol is a synthetic alkylbenzene oil.

It is planned to replace the oil after a reasonable initial run-in period. The initial charges of Zerol will be sacrificed as a flushing agent to get rid of any POE oil in the evaporator.

Note: Total system charge of R-422B was 45 pounds.

Fan Motors, Blower Wheels and Fan Housing Assemblies:

A single evaporator fan motor solution will not be used. Two “standard stock” evaporator fan motors will be used.

The fan blower housings were converted to belly band mounting assemblies. Because the fan housings were aluminum, the aluminum housings were strengthened with additional aluminum pieces custom cut to fit. Only the top half of the housing was reinforced. Two of the three mounts for the belly band attached to the top half (and thus the reinforced section). The third mount was on the bottom half. That mount actually attached to the steel fan mounting bracket.

The housings were in reasonably good shape. Because of the good condition of the aluminum housings, it has to be questioned if these are original, or not.

Photo #25: Aluminum reinforcement panel installed on aluminum fan housing

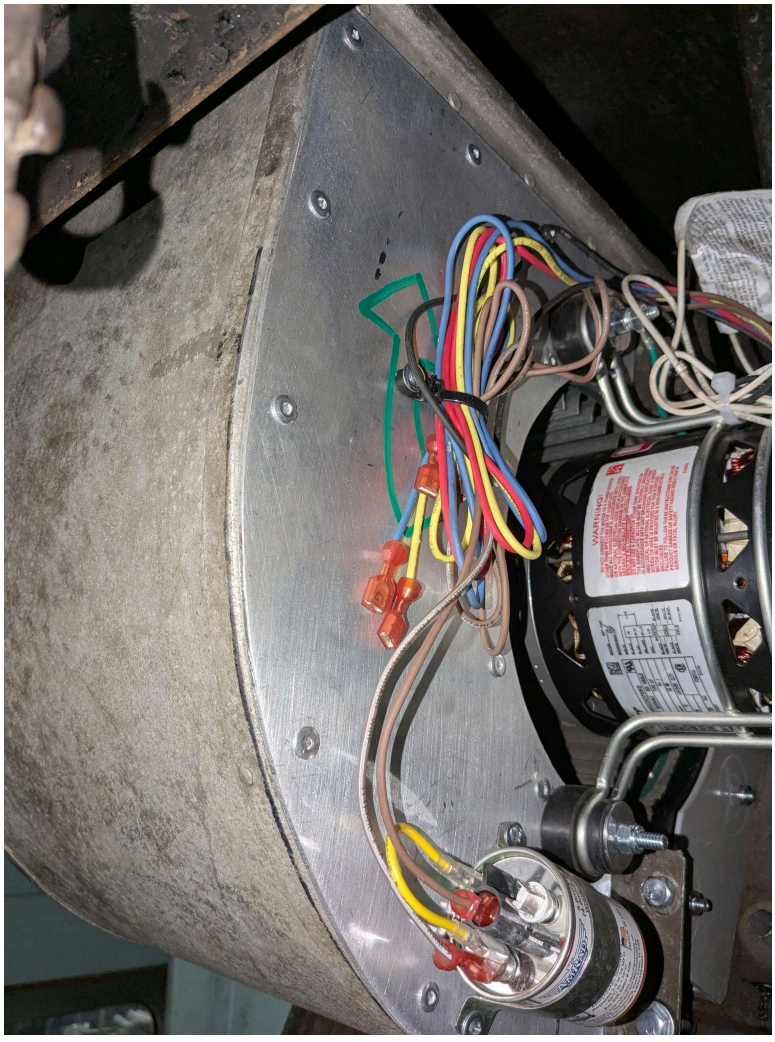


Photo #26: Belly mounted, frame 48, ¾ HP fan motors of PSC design.



Lau 9 x 9 fan wheels were already installed and will be reused. Many factors went into this decision. Including time and budget. The exact Lau model number is: DD9-9A. One blower wheel is Clockwise (CW), the other is Counter Clockwise (CCW). The are 43 blade wheels. The 9 x 9 Lau fan wheel seems to be a good replacement for the original size wheel of 10 x 9 as the actual dimension of the modern 9” Lau wheel is 9.5 inches. They fit reasonably well inside the housings. Certainly good enough, for now. A 10 x 9 wheel would have most certainly been fitted and tried out had one been available.

Note: By having a CW and a CCW blade, the fan hub set screws are on the outside of the fan. Thus, the fan motor does not interfere with the access to the set screw. If the same fan housing was used in both fan housings, on blade would have the setscrew on the fan motor side. That setscrew would be difficult to get at. If other fan wheels are considered, it would be necessary to assure that they are available in CW and CCW rotation.

Information Panel #6: Lau squirrel cage fan wheels used

Rotation options for Lau DD9-9A fan blades:

Clockwise (CW)	Part number 013332-01
Counterclockwise (CCW)	Part number 013332-03

For 8 tons of cooling, a minimum of 3,200 cfm of airflow is desired (assuming 400 cfm per ton). Because there are two fan housings operating in parallel, each housing must deliver 1,600 cfm. To engineer that, the fan static pressure of the air system must be known. No engineering data is available for that. A best estimate of 0.8" W.C. was used. This is very reasonable and was confirmed by some reverse engineering work. Also, 0.8" seems likely because of the existence of the steam / hot water coil.

The Lau 9 x 9 wheels will be used. This is good because Lau engineering data is available. See Diagram #1 below. Also, the Lau fan wheels have ½" hubs. The fan motors had ½" shafts. No machine shop service was required.

It has been determined that the Lau 9 x 9 wheels will deliver 1,600 cfm, at 0.8" W.C. total static at 1,120 rpm. The power required to do so is slightly over ½ HP. This seems very reasonable as the original 32 Volt DC motor was also 1,120 rpm. Because the HP is slightly over ½ HP, ¾ HP motors will be used. This is good because if the static pressure is actually higher than 0.8" W.C., the fan motors now have the power. From a cost and availability standpoint, ¾ HP motors are just as available and not much more expensive.

From these calculations, it can be seen why the single ¾ HP motor, which was in service, was a bit undersized. Two motors will be used with ¾ HP each for a system total of 1-½ HP. This is easily enough power for today, or any future upgrades.

Photo #27: Both fan motors installed but not yet wired permanently. Note: Ease of service.



Diagram #1: Lau engineering data for Model DD9-9A fan wheels

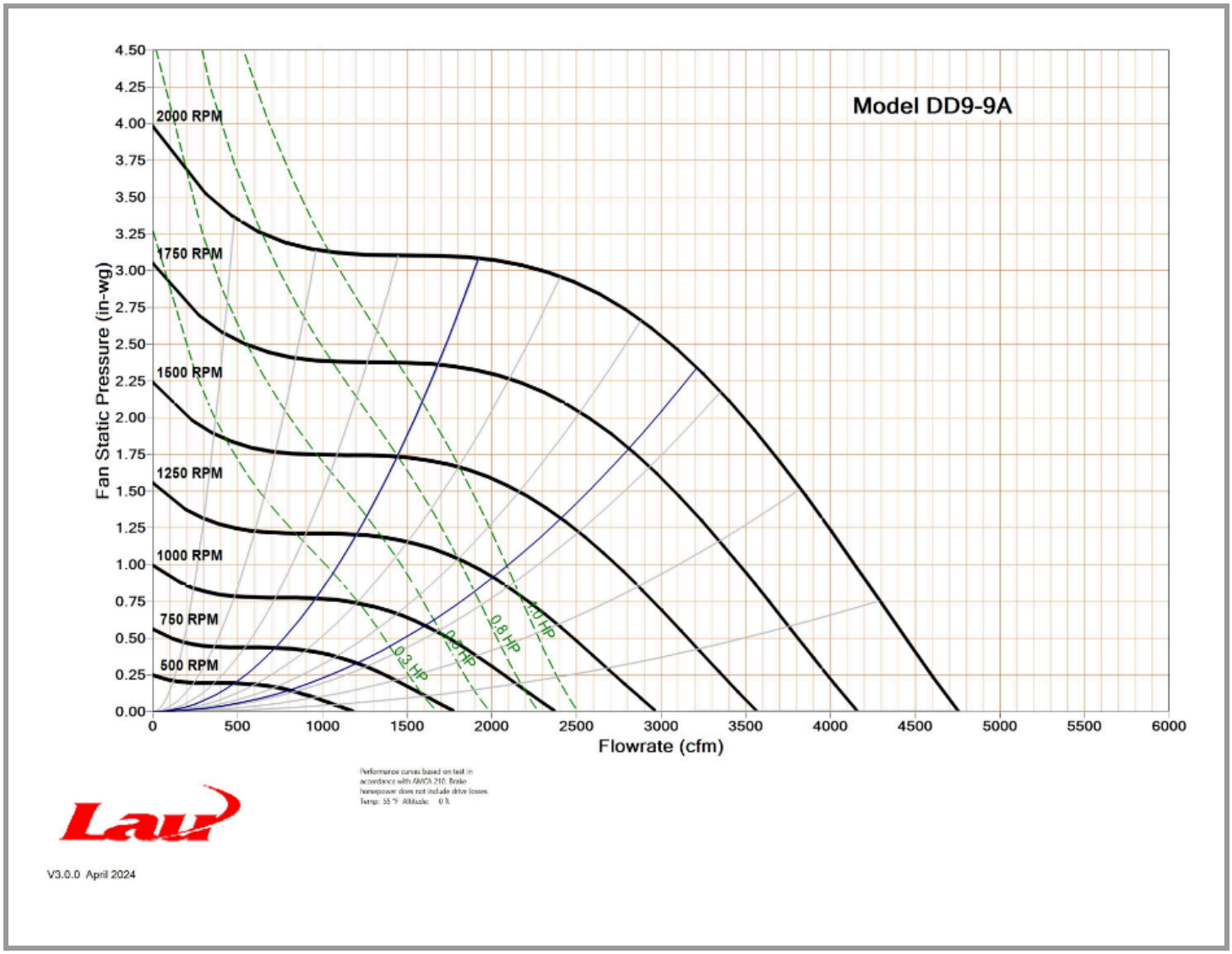
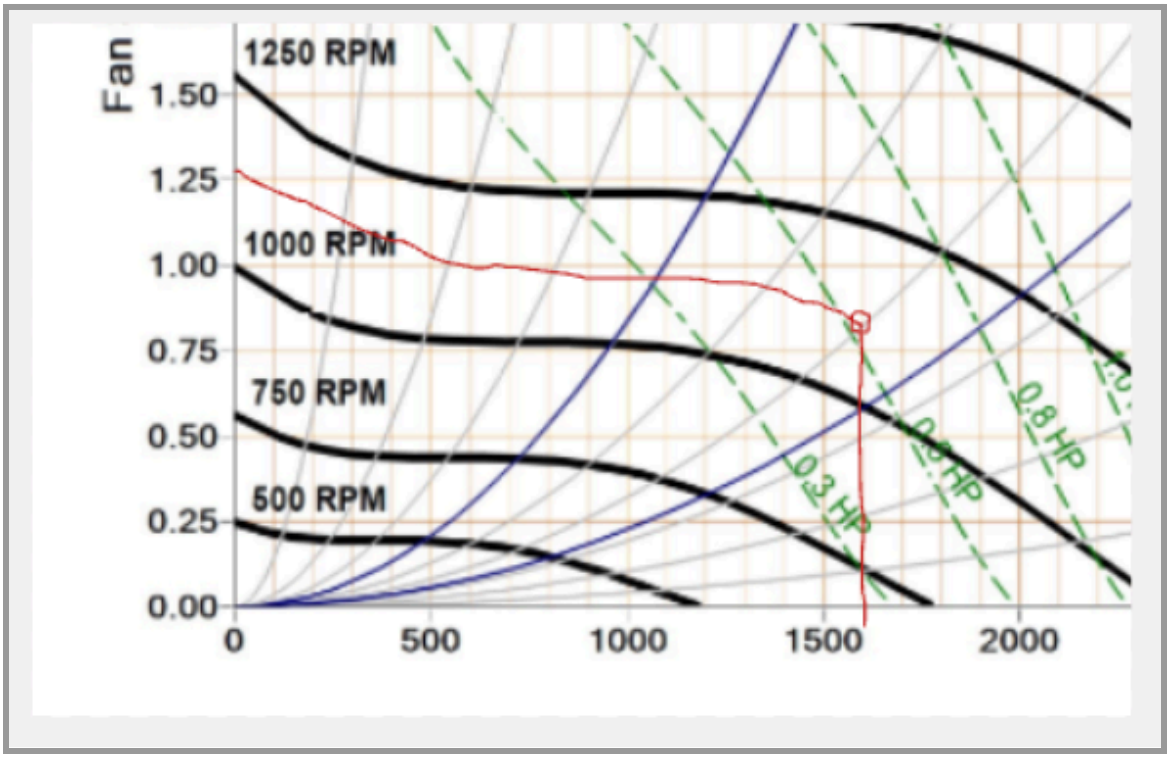


Diagram #2: Lau DD9-9A information specific to car 1213 and the desired 1,600 cfm



Each fan housing was converted to a modern belly band mounting system. With this conversion, standard frame 48 motors were used. These motors are ¾ HP, single phase and PSC design. This is very desirable as the fan assembly now consists of standard stocked motors, capacitors and blower wheels. No longer is anything about the fans special.

The fan motors will be 208 / 230 Volt operation. These motors are 1,075 rpm. The motors actually have 4 speeds. Only High speed will be used for cooling. 10uF capacitors were included with the motor. Also being implemented in the control system is slower fan motor speeds for ventilation or heating operation if/when electric heat is installed.

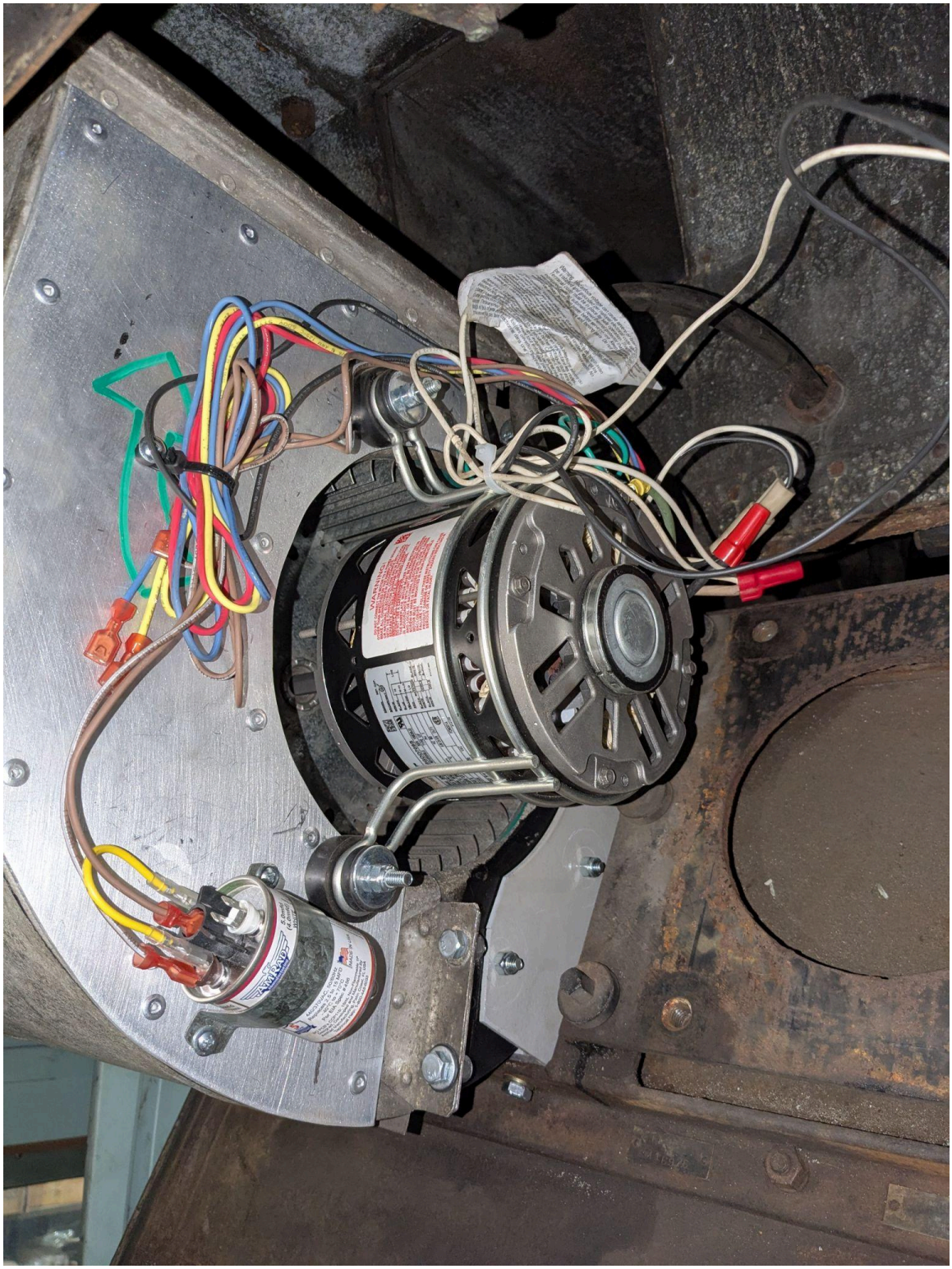
In the end, getting a full 1,600 cfm from these 1075 rpm motors and the 9x9 wheels just isn't possible. This will be discussed more in the conclusion. There is no "reasonable" way to get a slightly higher speed. Using a VFD was considered and dismissed as impractical.

Motors with ball bearings were chosen. These motors offer a long service life. The motor must have at least a 5 inch long shaft.

Photo #28: Fan motor used (x2)



Photo #29: Close up of evaporator fan installation and belly mount bracket



Electrical Controls:

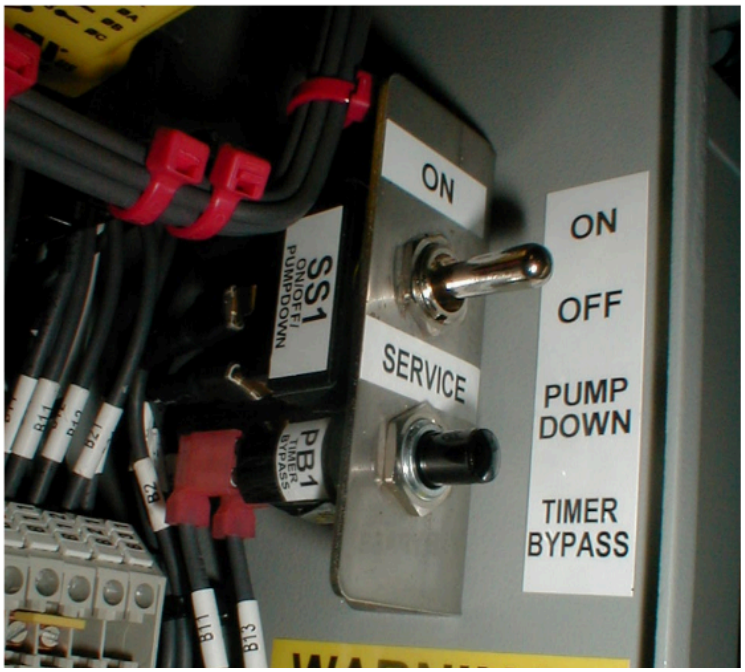
The system will be run as a single stage of cooling. The single refrigeration solenoid valve will feed both expansion valves. The evaporator will operate as a single circuit.

The control system will have an evaporator fan interlock mechanism so the condensing unit cannot start until High speed fan operation is established.

No operator intervention at the Northwest Rail Electric condensing unit is required for normal day-to-day service. SS1 on the Northwest Rail Electric condensing unit will be left in “ON” (Automatic mode) throughout the operation season. This is done by switch SS1. There is no reason for the operator to access the control panel of the Northwest Rail Electric condensing unit for day-to-day operation.

The car operator will have a switch for Air Conditioning Off / Automatic operation as well as Fan On / Off. Once in Automatic and the fan is On, the AC system will operate off normal thermostatic control for cooling. A call from the thermostat for cooling will enable the liquid line solenoid and a Compressor Call to the condensing unit. The Northwest Rail Electric condensing unit will start and stop automatically.

Photo #30: Northwest Rail Electric SS1 “ON” position for “Automatic” operation



Lessons Learned During System Installation and Startup:

Evaporator Fans:

Note: At the time this was written, the two evaporator fans were running across the line at 1075 rpm. The fans will not deliver the desired 1,600 cfm. This will have some impact on the performance of the refrigeration system and airflow to the blind end of the car.

- The two belly mounted ¾ HP motors work wonderfully! This was absolutely the right thing to do.
    - At 1075 rpm, the fans are relatively quiet and vibration free
        - It is noted that one of the wheels was not as well balanced as the other wheel was. It is suspected that one of the balancing tabs was accidently knocked off the wheel during rough handling at the time of the original installation.
    - Future service and replacement of a single evaporator fan motor will be cheap and much more easily done. These motors will be in stock for decades to come. These motors could be reasonably serviced and replaced in the field without the car having to come back to the shop.
- The air outlet furthest away from the fan section is perhaps the round discharge register in the ceiling of the Ladie's Room. Airflow was not recorded at the register. However, "good" airflow could be felt.
- Lau does make a 10 x 9 fan wheel. The model is DD10x9A. The original fan was a 10 x 9. The DD10x9A is a 48 blade fan as opposed to a 43 blade. It looks like there is enough room in the housings for this larger diameter fan wheel. With this fan, the fan blades would be completely inside to circular opening. It would be extremely interesting to see how this wheel fits. This wheel would have greater air flow. The 10 x 9 wheel also has the same ½" bore.
    - It is noted that the fan size is somewhat "nominal" and not all 10 x 9 fan wheels will be the same size.
- Even though I do not have the engineering date for the Lau 10 x 9 wheel, it is clear that this wheel would deliver the required 1,600 cfm at 1075 rpm. Perhaps even a little bit more. This would make things really nice and neat!
    - Remember that the DD9-9A wheels were used because they existed. Certainly, the ¾ HP double shaft motor that was previously installed could not have turned two DD10-9A wheels. But, the ¾ HP fan motors now installed certainly will.
    - If the project included getting new fan wheels, it would be interesting to try the larger size wheel. The extra airflow certainly would be beneficial to system performance.
        - Lau DD10x9A CW Part number 013317-01
        - Lau DD10x9A CCW Part number 013317-04
    - It would be a fantastic test to record the airflow at the far register and compare what the two different fan wheel actually do! I hope to make that reality some day.

NOTE: *All future system conversions, from this museum or any other, should consider two belly mounted ¾ HP, frame 48, fan motors in a similar fashion as was done on car 1213.*

Refrigeration System:

The main questions are:

1. How is the somewhat oversized condensing unit going to operate?
2. How are the expansion valves going to operate with the evaporator?
    a. Included in the discussion are the C type power assemblies and distributors

System startup was textbook perfect. Everything went so smoothly, it was almost lackluster. No issues were encountered. This is a real testimony to the high quality equipment used (Northwest Rail Electric condensing unit, Sporlan expansion valves and the 1950 Frigidaire coil itself).

The two Sporlan expansion valves worked as designed and engineered. As previously noted, the valves were opened up one full turn when installed. No additional adjustment for superheat was necessary. Sporlan balanced port valves are the clear answer.

There is no discussion on the C power assemblies as opposed to the VP-100 assemblies which were requested. It turned out to be a non-issue with this condensing unit. Nothing more can be said.

The distributors fed well. By visual inspection and noting the temperatures of the U bends on the coil, it was obvious by inspection that the distributors were feeding properly and evenly. All passes of the coil appeared to be feeding evenly. The initial conclusion is confirmed. There is no need to replace the distributors.

It should be mentioned again. The importance of pressure testing the evaporator coil(s) early in the project was absolutely the correct first step. Had this coil been a leaker, the project would have been way different!

Photo #31: Distributors showing even feeding (even condensation)



The suction pressure was somewhat low because of the greater capacity of the condensing unit and a somewhat low airflow across the evaporator. Airflow has been greatly discussed in this document as it's a real issue. As expected, the hot gas bypass valve was modulating. Thankfully, this unit has the hot gas bypass system. Adjusting the Parker A9E hot gas bypass valve to 48 psig was easily accomplished. The Parker valve adjustment was crisp and precise. The initial adjustment setting from the factory was very close. The factory Sporlan desuperheater valve worked perfectly and required no adjustment.

On startup day, the temperature inside the car wasn't terribly warm. The car was also inside the shop and had no solar load. The temperature inside the car pulled down rapidly. The ladies room, which is at the end of the ductwork, was receiving cool air and was comfortable. This is perhaps the most critical zone. As noted, a bit more airflow would be welcomed. With an outdoor RH of about 48%, the coil was producing about ¾ gallon of condensate per hour. The RH of the return air was most likely less even though the cabin door was wide open.

After a 24 hour run-in period, the oil and liquid line filter was replaced. Zerol 150 will continue to be used. The original oil was contaminated from scrubbing the POE oil out of the evaporator coil. The Zerol oil isn't cheap! However, even at $90 per gallon, changing the oil was absolutely necessary. In fact, because there was time in the test run period, the oil was changed a second time prior to the car's departure.

Car 1213 will be returned to service in 3 weeks after system startup. The AC system will remain in operation during this 3 week period. This will result in a very sufficient test period.

It should be noted that the initial startup of the condensing unit was done with “temporary” off shore power. The Stadco generator was not yet fully installed and in service. During the next 3 weeks, power for the condensing unit will be transferred from the extension cord (shore power) to the Stadco generator. At that time, the run test of the AC system will require the generator running. Car 1213 may have to be moved out of the shop at that time.

Refrigeration Piping:

The fact that the stubs are soft soldered on the suction header of the coil, perhaps a different approach will be used next time. The existing piping was cut off at the stub. But then, another fitting was immediately soft soldered on. Next time, additional thought will be given into where to cut off the existing piping. It may be better to cut the piping off further downstream. There are no reservations in leaving some Stay Brite soldered joints behind.

It is felt that replacing all the piping inside the car, including the original heat exchanger was the right decision. The original 2-⅛” heat exchanger would most likely cause oil return issues.

The insane amount of work to remove, and re-install, the pipe chase cover must be considered! However, the ceiling in the men’s lavatory was also laboriously removed. This allowed decent access to the area where the refrigeration pipes were re-soldered and brazed. Without the ceiling removed, it may not have been possible to do the required pipe fitting and welding.

Next time: Do the work to physically remove the toilet. Room is so cramped, just go ahead and remove the toilet.

It may be best to do whatever is necessary to keep all the suction piping in the existing chase way under the car. In the case of car 1213, that would have meant dropping the septic tank. It was possible to get the 1-⅜” piping into the chase way in full 15 - 20 foot lengths. The extra effort to get the piping into the chase would have probably been less work than going around the tanks (diesel and septic) and making Unistrut brackets. For sure, the piping has to be in the chase above the truck.

The exposed copper piping now invites theft as it is very visible. The suction line is insulated with black closed cell insulation which may conceal the pipes true identity. However, the liquid line is obvious and quite accessible. The copper liquid line was painted black to help hide the copper pipe’s true identity.

The brass flare fitting on the TXV outlet can be built with a long radius elbow and a straight brass fitting. This would reduce pressure drop at that area. That should be done next time.
Idea: 50635K583 from McMaster - Carr and a 90 degree long radius street elbow.

Final Thoughts for the Full Airflow of 1,600 cfm:

1,600 cfm per fan did not happen. VFDs just aren't an option. The only true option is the Lau 10 x 9 fan blade assemblies. For now, the AC system in car 1213 moves forward with what it has. If / when the car returns for service and maintenance, and if budget allows, and if there is volunteer power to do the work, it would be great to replace the fan wheels. Until then, we did what we could with what we had. Good enough is simply good enough. To that end, the AC works phenomenally well. However, there is always room for "even better". I'll leave it at that.

Duration of Project:

The project consisted of engineering, decommissioning, asbestos abatement (by a professional service), demolition, construction (piping and wiring) and test running.

The project had a goal of the AC system running in the month of July. Whereas the evaporator fan motor work was done and test running in July, the actual start date of the refrigeration condensing unit was August 5th, 2026.

- All stages of construction: About 4+ months (early May through July)
- Test running in the roundhouse shop prior to going to the field: About 3 weeks (early to end August)
- The factory startup from Stadco was performed on September 2nd, 2026.
- Return to service: Mid September, 2026

The return to service date was met. Car 1213 left the Jackson Street Roundhouse on September 10th, 2026.

How the goals can be measured:

- Build an air conditioning system which is leak free
    - Refrigerant loss from prior years can be compared to refrigerant loss going forward
    - The goal is to have near zero refrigerant loss year after year
- Build an air conditioning system which is mechanically reliable
    - Down time from prior years can be compared
    - Reliability between this unit versus the remaining units of the fleet can be noted
- Build an air conditioning system which will operate in an automatic mode
    - The car operator will start and stop the AC system entirely from inside the car
    - No operation under the car will be necessary for daily operation
    - The air cooled condenser on the Northwest Rail unit does not require water
- Build an air conditioning system which will be significantly easier to maintain
    - Use of parts which are currently common stock at most HVAC supply houses
    - Use a modern condensing unit which is far easier to maintain
    - No belts or rotating shaft seals
    - No frequent water refills
- Build an air conditioning system which will be less expensive to maintain
    - No refrigerant loss
    - Common parts which are reasonably priced
- Build an air conditioning system which uses modern refrigerants and oils
    - R-422B will be used with Alkybenzoil oil
- Establish a pattern for future conversions by this museum, or others
    - Document and record the process and solutions
    - Look for ways the next conversion can be better