Johnson Controls Unitary Products
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DATE: **June 20, 2012** **ST-022-12**

SUBJECT: **Recommended Refrigerant Charging for HVAC Systems**
Read All Methods Before Starting

Background & Purpose:
The purpose of this application bulletin is to provide basic, easy to follow procedures for proper refrigerant charging. Proper refrigerant charge ensures optimum system performance, reliability, and cost effective installation. This is important for split systems which require care in calculating refrigerant charge amounts based on the particular installation and lineset.

With the advent of MicroChannel condenser coils, a number of advantages over conventional coils include higher efficiency, smaller size, and environmental friendliness due to lower amount of refrigerant required to achieve the same cooling capacity. Due to the reduced charge volume, MicroChannel coils tend to be less tolerant of improper charge amounts. While this charging procedure should be used for all coil technologies, it is particularly important for MicroChannel based cooling systems.

Why Four Different Procedures
An installer might face six different scenarios in charging. There are two different "system types", split and packaged systems. For each of these system types there are three different scenarios that involve charging or verifying a unit is operating properly. These scenarios are: new system installation, retrofit system installation, and leak repair of an existing unit. The procedures are depicted as follows:

System Type	New System Installation	Retrofit System Installation	Leak Repair
Split	A	B	C
Packaged	D	D	C

Although there are six different scenarios, the same charging procedure is used for repairing packaged and split systems and for new and retrofit installation of packaged units, therefore there are only four procedures.

All four procedures use common tools and materials. These are outlined in the section labeled "Tools & Materials". The four procedures are then outlined in the following sections labeled A through D, as follows:

Procedure	Section Heading
n/a	Tools, Materials, & Charging Chart Examples
n/a	Charging Chart Examples
A	Split System – New Installation
B	Split System – Retrofit Installation (utilizing existing line set)
C	Leak Repair - Packaged and Split
D	Package Units - New & Retrofit Installations

These procedures are written to prevent inadvertent system overcharge, and provide basic guidance for accurate charge verification. These procedures are consistent with standard industry practices and work well if followed as written. While proper charging is more critical in MicroChannel applications, these procedures can be used for any system, whether MicroChannel or traditional fin/tube designs. These procedures can easily be mastered by technicians who are EPA refrigerant handling certified and are familiar with standard industry practices related to refrigerant system maintenance.

If you have questions regarding charging procedures, please contact your local distributor or Johnson Controls Unitary Products Technical Services at 877-874-7378 (877-UPG-SERV).

Bruce Porter
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Tools and Materials

To properly charge MicroChannel product, it is important that the correct tools are used and are properly maintained and calibrated. (Refer to manufacturer's instructions.) These tools include:

- Vacuum pump capable of achieving < 500 micron vacuum – (the pump should be charged with fresh oil following each use).
- Micron gauge – capable of reading 500 microns or less.
- Gauge manifold set for appropriate refrigerant.
- Weight scale for measuring refrigerant charge.
- Tape measure – to measure line set distances.
- Calculator & notepad – to execute and document calculations.
- Industry-approved refrigerant recovery equipment.

Materials Required:

- Nitrogen - at least a "B" tank and 3-stage regulator so pressures up to 400 psig can be attained.
- Filter drier – must be replaced every time a refrigeration system is opened
- New refrigerant – quantity as required.
- Brazing rig – including braze gases, 15% silver braze rod or higher.
- Personal protection equipment (all industry safety practices must be followed)
- Leak detection equipment (electronic leak detector and soap solution)
- MicroChannel repair kit (Source One #S1-37327803001)
- Acid test kit (in case of a compressor burnout)

Charging Chart Examples

These examples of superheat & subcooling charging charts (Figures 1 & 2, respectively) are referred to in the attached procedures. Please note these are examples only. Refer to the chart supplied with the outdoor unit for actual superheat and subcooling values, and the installation manual for detailed step-by-step instructions.

Figure 1: Example Superheat (Orifice) Chart

Superheat Charging Chart																
Outdoor Ambient DB (°F)	Suction Pressure (psig) / Suction Temperature (°F)															
	117	120	123	126	129	132	135	138	141	144	147	150	153	156	159	162
65	58	62	65	68	71	..	..	..	..	..	..	..	..	..	..	..
70	55	58	61	65	68	71	..	..	..	..	..	..	..	..	..	..
75	..	54	58	61	64	67	70	..	..	..	..	..	..	..	..	..
80	..	..	53	57	60	63	67	7	..	..	..	..	..	..	..	..
85	..	..	..	53	56	60	63	6	70	..	..	..	..	..	..	..
90	..	..	..	..	53	56	59	62	65	68	..	..	..	..	..	..
95	..	..	..	..	..	53	56	59	62	65	68	..	..	..	..	..
100	..	..	..	..	..	..	53	56	59	62	65	68	..	..	..	..
105	..	..	..	..	..	..	..	53	56	59	61	64	67	..	..	..
110	..	..	..	..	..	..	..	..	54	56	59	62	64	67	..	..
115	..	..	..	..	..	..	..	..	..	55	57	60	62	65	67	..
120	..	..	..	..	..	..	..	..	..	..	56	58	60	62	64	66
125	..	..	..	..	..	..	..	..	..	..	..	56	58	60	62	64

In this example, suction pressure is 138 psig and outdoor ambient temperature is 95 degrees F. Suction temperature is inclusive of superheat of 11 degrees (from P/T chart interpolation).

Based on the chart, if suction temperature is less than 59 degrees, then charge should be removed. If suction temperature is more than 59 degree, charge should be added. Add/remove charge in 1 ounce increments and let stabilize for 10 minutes. Repeat process until proper suction temperature is reached.

Figure 2: Example Subcooling (TXV) Chart

Subcooling Charging Chart				
Outdoor Ambient DB (°F)	Indoor Wet Bulb (°F)			
	57	62	67	72
	Liquid Pressure (psig) at Base Valve			
65	207(5)	208(5)	21 (6)	214(7)
70	228(6)	228(6)	23 (7)	233(8)
75	250(7)	250(7)	25 (8)	255(8)
80	274(8)	273(8)	27 (9)	278(9)
85	299(9)	298(9)	302(10)	302(10)
90	326(10)	324(10)	329(11)	328(11)
95	354(11)	352(11)	358(12)	356(12)
100	384(12)	381(12)	388(13)	386(12)
105	415(13)	413(13)	419(14)	417(13)
110	448(14)	445(14)	453(15)	449(14)
115	482(15)	479(14)	488(15)	484(15)
120	518(16)	515(15)	524(16)	519(15)
125	555(16)	553(16)	563(17)	557(16)

In this example, liquid pressure is 329 psig and outdoor ambient temperature is 90 degrees F.

Based on the chart, subcooling is 11 degrees at 67 degrees F indoor wet bulb and 90 outdoor ambient. If liquid pressure is less than 329 psig, then charge should be added. If liquid pressure is more than 329 psig, then charge should be removed. Add/remove charge in 1 ounce increments and let stabilize for 10 minutes. Repeat process until proper liquid pressure is reached.

Charging Procedure "A"
Split System – New Installation

This section deals with charging procedures for new split systems installation. One key to accurate split system charging is to understand the line set volumes and to calculate charge adders accordingly. Prior to beginning the charging procedure, it is assumed that:

- The system is installed, the line set brazed in and the system is ready to be charged. For residential condensing units, service valves remain closed; for commercial splits, service valves remain open.
- Indoor system is adjusted to nominal airflow conditions (refer to Technical Guide).
- Indoor coil is factory-matched to the outdoor condensing unit. If not, additional steps are required (see below).
- Line set volumes are determined using the Comfort Cooling Piping Program available on UPGnet. An addition in charge value may be required based on refrigerant and hose volume as described in step 3 below.

Step 1 – Verify system integrity Verify line set and indoor side system integrity by conducting a static test (400psig with dry nitrogen), and confirm there are no leaking braze joints. Check with soap solution. Repair leaks as required. After verification, release nitrogen from system.

Step 2 – Evacuation Install manifold gauge set to condensing unit service valves. Take center hose of gauge set and attach to the micron gauge. Connect 4th hose from micron gauge to inlet side of vacuum pump. Start the vacuum pump, turn on the micron gauge, and open both manifold valves to the back seated position. Pull a vacuum on the system until micron gauge reads 500 microns or less. When achieved, close the vacuum pump inlet valve and shut off the vacuum pump. Monitor system pressure. Once 500 microns is attained, close manifold gauge set; remove the micron gauge and 4th hose. If 500 microns cannot be achieved, inspect all refrigeration hoses and repeat steps 1 and 2.

Step 3 – Determine charge volume addition (over and above name plate volume) For factory matched systems, determine volumetric system charge adder based on line set and indoor coil calculations from outdoor unit tech guides. Line set volumes are determined using the Comfort Cooling Piping Program available on UPGnet, or use the Piping Application Guide (247077-UAD-H-0209). Please note that the charge volume assumptions due to residual liquid in the gauge set hoses should be incorporated into the calculation. Here are examples of refrigeration hose charge volumes:

Ounces of liquid held per foot of hose at 80° F							
Hose type	**R-12**	**R-22**	**R-134a**	**R-404A**	**R-407C**	**R-410A**	**R-502**
1/4" Original	0.36	0.33	0.33	0.29	0.31	0.29	0.33
1/4" *PLUS II*™	0.36	0.33	0.33	0.29	0.31	0.29	0.33
1/4" Heavy duty	0.34	0.31	0.32	0.27	0.30	0.28	0.32
3/8" *PLUS II*™	0.85	0.77	0.78	0.67	0.73	0.68	0.78
3/8" Heavy duty	0.85	0.77	0.78	0.67	0.73	0.68	0.78
1/2" Heavy duty	1.85	1.68	1.70	1.47	1.60	1.49	1.71
3/4" Heavy duty	3.89	3.53	3.58	3.09	3.37	3.13	3.60

Chart used with permission of Ritchie Engineering / Yellowjacket

The use of non AHRI matched coils is not recommended. If a 3rd party AHRI matched indoor coil is used, refer to the 3rd party manufacturer for charging information. In lieu of 3rd party AHRI matched manufacturer's charging information, use the factory matched coil charging information, recognizing that the charge will likely require further adjustment (charge addition or removal) during the charge verification process as defined in Step 8. Document calculated charge adder on startup sheet in the installation packet.

Step 4 – Setup refrigerant Make sure the refrigerant the the cylinder contains sufficient refrigerant to complete the charge addition. Connect the refrigerant cylinder to center hose on manifold set. Open the the the cylinder valve and purge hose to gauge manifold set. Place cylinder on scale oriented to charge in liquid phase and calibrate scale to "zero".

Step 5 – Introduce condenser charge to the system Allow vacuum to pull in refrigerant until calculated amount is reached. If this cannot be done, wait until equalization occurs, then open service valves to balance the rest of the charge while unit is running. Open liquid valve on unit and back seat. Open suction valve on unit and back seat. Replace both service valve caps, hand tight and then tighten with a wrench. Wait until the charge equalizes through the system (about 2 minutes).

Step 6 – Start system Obtain indoor wet bulb reading. This reading is a key input to the factory charging chart posted in the Installation manual and on the unit electrical cover, which is used to determine proper charge. Set the thermostat for cooling call and energize system. Observe system for nominal airflow and condensing unit operation. Let the unit stabilize for 10 minutes. Depending on indoor loading conditions, run time should be extended until indoor wet bulb is within the range of the charging chart (note: depending on the indoor temperature, this process could take up to several hours).

Step 7 – Introduce calculated charge volume addition (This is the amount of charge calculated in step 3). Slowly open suction manifold valve and monitor refrigerant scale until volumetric charge adder is met. Remember to add ounces for volume present in hoses to avoid overcharging the system. (On Pkg equip refer to charging chart in the installation manual)

Step 8 – Validate charge value is correct and system is operating properly Continue to monitor the system until stabilized, typically 10-15 minutes. Please refer to the charging charts on the condensing unit to determine proper subcooling (for TXV applications) or superheat (for orifice applications). The charts are based on outdoor ambient conditions. If such information is not available in the installation manual or the electrical cover, please contact Unitary Products Technical Services at 877-874-7378.

The subcooling and superheat charts on Figures 1 and 2 are examples of how to validate the correct charge and make further fine-tuning adjustments, if necessary.

Step 9 – Record your data Record the total system charge line set length and date on inside panel. This should be done adjacent to wiring diagram. This will be useful for the next service technician. Document required startup & commissioning data in factory provided startup sheet.

Charging Procedure "B"
Split System – Retrofit Installation (Utilizing Existing Line Set)

This section deals with charging split system condenser replacements. For split system retrofits, it is important to assess the integrity of the existing line set, particularly if the initial unit used R-22 refrigerant whereas the replacement system uses R-410a. Therefore, this procedure is setup in two parts, "Preparation for Charging" and "Charging Procedure".

On some jobs it is acceptable to utilize the existing line set when it is not practical to install a new one and the line set meets current standards for line sets for R-410a. If using the existing line set, a thorough cleaning is required as described in the procedure below, and cleanliness must be maintained while the refrigeration system is opened. Additional cautions: if the existing line set was brazed with a low pressure tin based solder as was used early in the R-22 era, the line set must be replaced as it will not accommodate the higher pressures of R-410a. The line set must also be replaced if it is not sized properly for R-410a refrigerant velocities as defined by the Comfort Cooling Piping Program found on UPGnet. (247077-UAD-H 0209)

Preparation for Charging

Step 1 - Verify line set integrity visually, particularly for evidence of corrosion If there is evidence of corrosion or if there is tin based solder on the original installation, the line set must be replaced. Measure the length of the line set, the number of elbows present, and any elevation differences (compressor low or high in relationship to the evaporator) in order to properly calculate the new charge volume.

Step 2 - Uninstall previous equipment using EPA industry standards (recovery and disposal) Use a tubing cutter when cutting tubing to prevent burrs and chips. If a torch is used to disassemble tubing, a 1 psig nitrogen purge must be used during this process. Remove equipment. Once the condenser is removed, all that should remain is the existing line set.

Step 3. Clean existing line set This can be done by two different methods.

1st method - Use high pressure dry nitrogen This method can be used when the line set is relatively short (<25') and there are no visible places to trap oil. This procedure requires prep work to contain oil as it exits the system. Place a rag on the tubing at the end of each line outside the condenser. Then bend the rag back over the tubing and secure with strong duct tape or equivalent. This will eliminate oil spray that could occur when the high pressure nitrogen is introduced. On the inside of the building where the evaporator is located, setup 1psig nitrogen purge, then braze in a Schrader connection to each line that has the core removed. Pre-adjust regulator on nitrogen cylinder to 400psig. Place a high pressure hose, one suitable for R-410A on one of the connections and introduce in high pressure bursts 3 to 5 cycles of nitrogen into the line for 3 to 5 seconds. Go outside and check to see how much oil was purged. Visually this should be a very small volume if any. If satisfied that the line has no more oil to purge, then proceed to the second line and repeat process. When complete, cut the end of the indoor lines using a tube cutter, saving your Schrader connections for installation of new equipment indoors and outdoors can continue using nitrogen during the brazing process. No new drier is required.

2nd method; Use an industry approved flush kit, then high pressure dry nitrogen This method should be used when line set is over 25' and has places to trap oil or possibly portions of line set that cannot be visually inspected. Purge cleaning solution through the line set per manufacturer's instructions. Then, use the same procedure as in the 1st method after completing the purge with cleaner. Repeat the process stated in 1st method and cycle high pressure bursts of nitrogen through system.

Step 4. Install new R-410a equipment Ensure there is a dry nitrogen purge of 1 psig is present during brazing. Verify the proper metering device (TXV or orifice) on the equipment. Refer to the installation sheets and tech guides supplied with the outdoor unit for data. Filter driers should be installed at this point (note: residential units already have one installed). Under most circumstances, the factory installed filter drier in the condensing unit should be adequate. If there is a concern with system component cleanliness, a suction line filter drier can be added.

Step 5. Pressure test system with 400psig and leak check all brazing If system integrity is present proceed with "Charging Procedure" below.

Charging Procedure

This section deals with charging procedures for new split systems installation in a retrofit application. One key to accurate split system charging is to understand the line set volumes and to calculate charge adders accordingly. Prior to beginning the charging procedure, it is assumed that:

- The system is installed, the line set brazed in and the system is ready to be charged. For residential condensing units, service valves remain closed; for commercial splits, service valves remain open.
- Indoor system is adjusted to nominal airflow conditions (refer to Technical Guide).
- Indoor coil is factory-matched to the outdoor condensing unit. If not, additional steps are required (see below).
- Line set volumes are determined using the Comfort Cooling Piping Program, available on UPGnet. An addition in charge value may be required based on refrigerant and hose volume as described in step 3 below.

Step 1 – Verify system integrity Verify line set and indoor side system integrity by conducting a static test (400psig with dry nitrogen), and confirm there are no leaking braze joints. Check with soap solution. Repair leaks as required. After verification, release nitrogen from system.

Step 2 – Evacuation Install manifold gauge set to condensing unit service valves. Take center hose of gauge set and attach to micron gauge. Connect a 4th hose from micron gauge to inlet side of vacuum pump. Start vacuum pump, turn on micron gauge, and open both manifold valves to back seated position. Pull vacuum on system until micron gauge reads 500 microns or less. When achieved, close vacuum pump inlet valve and shut off vacuum pump. Monitor system pressure. Once 500 microns is attained, close manifold gauge set; remove micron gauge and 4th hose. If 500 microns cannot be achieved, inspect all refrigeration hoses and repeat steps 1 and 2.

Step 3 – Determine charge volume addition (over and above name plate volume) For factory matched systems, determine volumetric system charge adder based on line set and indoor coil calculations from outdoor unit Technical Guides. Line set volumes are determined using the Comfort Cooling Piping Program available on UPGnet, or Piping Application Guide (247077-UAD-H-0209). Please note charge volume assumptions due to residual liquid in the gauge set hoses should be incorporated into the calculation. Here are examples of refrigeration hose charge volumes:

Ounces of liquid held per foot of hose at 80° F							
Hose type	R-12	R-22	R-134a	R-404A	R-407C	R-410A	R-502
1/4" Original	0.36	0.33	0.33	0.29	0.31	0.29	0.33
1/4" *PLUS II*™	0.36	0.33	0.33	0.29	0.31	0.29	0.33
1/4" Heavy duty	0.34	0.31	0.32	0.27	0.30	0.28	0.32
3/8" *PLUS II*™	0.85	0.77	0.78	0.67	0.73	0.68	0.78
3/8" Heavy duty	0.85	0.77	0.78	0.67	0.73	0.68	0.78
1/2" Heavy duty	1.85	1.68	1.70	1.47	1.60	1.49	1.71
3/4" Heavy duty	3.89	3.53	3.58	3.09	3.37	3.13	3.60

Chart used with permission of Ritchie Engineering / Yellowjacket

The use of non AHRI matched coils is not recommended. If a 3rd party AHRI matched indoor coil is used, refer to the 3rd party manufacturer for charging information. In lieu of 3rd party AHRI matched manufacturer's charging information, use the factory matched coil charging information, recognizing that the charge will likely require further adjustment (charge addition or removal) during the charge verification process as defined in step 8. Document calculated charge adder on startup sheet in the installation packet.

Step 4 – Setup refrigerant Make sure cylinder contains sufficient refrigerant to complete the charge addition. Connect refrigerant cylinder to center hose on manifold set. Open refrigerant cylinder valve and purge hose to gauge manifold set. Place cylinder on scale oriented to charge in liquid phase and calibrate scale to "zero".

Step 5 – Introduce condenser charge to the system Allow vacuum to pull in refrigerant until calculated amount is reached. If this cannot be done wait till equalization occurs then open service valves to balance the rest of the charge while unit is running. Open liquid valve on unit and back seat. Open suction valve on unit and back seat. Replace both service valve caps, hand tight and then tighten with a wrench. Wait until the charge equalizes through the system (about 2 minutes).

Step 6 – Start system Obtain indoor wet bulb reading. This reading is a key input to the factory charging chart posted in the Installation manual and on the unit electrical cover, which is used to determine proper charge. Set the thermostat for cooling call and energize system. Observe system for nominal airflow and condensing unit operation. Let the unit stabilize for 10 minutes. Depending on indoor loading conditions, run time should be extended until indoor wet bulb is within the range of the charging chart (note: depending on the indoor temperature, this process could take up to several hours).

Step 7 – Introduce calculated charge volume addition (This is the amount of charge calculated in step 3). Slowly open suction manifold valve and monitor refrigerant scale until volumetric charge adder is met. Remember to add ounces for volume present in hoses to avoid overcharging the system. For package equipment, refer to charging chart in the installation manual.

Step 8 – Validate charge value is correct and system is operating properly Continue to monitor the system until stabilized, typically 10-15 minutes. Please refer to the charging charts on the condensing unit to determine proper subcooling (for TXV applications) or superheat (for orifice applications). The charts are based on outdoor ambient conditions. If such information is not available in the installation manual or the electrical cover, please contact Unitary Products Technical Services at 877-874-7378.

The subcooling and superheat charts on Figures 1 and 2 are examples of how to validate the correct charge and make further fine-tuning adjustments, if necessary.

Step 9 – Record your data Record the total system charge line set length and date on inside panel. This should be done adjacent to wiring diagram. This will be useful for the next service technician. Document required startup & commissioning data in factory provided startup sheet.

Charging Procedure "C"

Leak Repair - Packaged and Split

The leak repair process for split systems & package units are the same, and are described in this procedure.
It is important that proper diagnostic tools be used to determine the source of leaks. This procedure is therefore written in two parts "Leak Detection & Repair" and "Recharging Procedure". To properly diagnose the location of a leak, always use high pressure nitrogen (400 psig) and an electronic leak detector or soap bubbles to confirm the leak location.

Note: most R-410A systems use highly hygroscopic "POE" lubricant oil, which means it absorbs moisture at a high rate when exposed to the atmosphere. For that reason, care must be taken to minimize the time the refrigerant system is open and to maintain proper nitrogen charge during repair. As part of the repair, new driers must be installed to capture remaining moisture left in the system.

If the outdoor unit is being repaired due to a compressor burnout (possibly caused by a refrigerant leak), it is likely that additional contamination is present in the refrigeration system. In this case, a 100% activated alumina suction-line filter drier is required to purge the system of the additional contaminants and acid. Additional steps are required to install a suction-line filter drier (Leak Detection & Repair – Step 5b) and purge the system of additional contaminants and acid (Recharging Procedure - Step 8B).

Leak Detection & Repair

Step 1 - Verify system integrity by checking system pressure Use a manifold gauge set to see if the system is still under pressure or if it is empty and void of charge. If the system is under pressure you may be able to leak check with the charge left in the system using bubbles or electronic testers. If not, the remaining charge must be recovered and disposed of or reused per EPA regulations.

After recovering the remaining refrigerant, note the weight removed. Reclaim to about 2 psig and directly introduce nitrogen under high pressure on top of the leftover refrigerant pressure. Then introduce 400 psig dry nitrogen into the system and test for leaks. At this time, access the evaporator section to check for the presence of refrigerant. In most cases you will hear the leak if it is obvious. Look for signs of oil as R-410a and oil bond, a leak will leave an oil trail. If system is void of charge and under nitrogen pressure, the leak cannot be either heard or visually seen, then you must use an electronic leak detector.

Step 2 – Electronic leak detection If the system is void of refrigerant and the above step yields no leak that can be seen or heard, use of an electronic leak detector is mandatory. Introduce 2 psig of refrigerant and increase pressure with nitrogen to 400psig. This is required so the detector can register a leak. Release of this tracer gas combination is considered a "diminimus release" and is allowable per EPA regulations.

Step 3 – Pinpoint leak location When the leak is found, use soap bubbles to get a pin point location. You might need an inspection mirror along with a bright flash light to accomplish.

Step 4 - Repair the leak If the leak is in the tube sheet of the MicroChannel coil (aluminum portion) the technician has the option of replacing the coil or repairing the coil using an aluminum repair kit available from Source One. If the leak is in the copper bearing portion of the system, then a 15% Sil-Phos/Silver may be used along with nitrogen purge at 1psig during this operation. A leak at the copper-aluminum joint should never be repaired in the field as this braze joint requires sophisticated process controls not normally available in the field. Such a leak requires a coil replacement.

Step 5 – Remove the original factory filter drier in the condensing unit, then install a new liquid line filter drier.

Step 5b – Add suction-line filter If the refrigerant system was opened to replace a compressor burnout, then a 100% activated alumina suction-line filter drier must be installed. After the system is operational, additional steps are required to run the system until contaminants are removed (see step 7b under Charging Procedure below).

Step 6 – Confirm leak repair For both split and package systems, after the leak repair verify full system leak integrity by conducting a static test (400psig with dry nitrogen), and confirm no system leakage. Check with soap solution. Repair leaks as required. After verification, release nitrogen from system.

Charging Procedure

One key to accurate split system charging is to understand the line set volumes and to calculate charge adders accordingly. Prior to beginning the charging procedure, it is assumed that:

- The system is installed, the line set brazed in and the system is ready to be charged. For residential condensing units, service valves remain closed; for commercial splits, service valves remain open.
- Indoor system is adjusted to nominal airflow conditions (refer to Technical Guide).
- Indoor coil is factory-matched to the outdoor condensing unit. If not, additional steps are required (see below).
- Line set volumes are determined using JCI'S / UPG Comfort Cooling Piping Program available on UPGnet. An addition in charge value may be required based on refrigerant and hose volume as described in step 3 below.
- For Package equipment the indoor air flow must be at nominal level for proper charging

Step 1 – Verify system integrity. Verify line set and indoor side system integrity by conducting a static test (400psig with dry nitrogen), and confirm there are no leaking braze joints. Check with soap solution. Repair leaks as required. After verification, release nitrogen from system.

Step 2 – Evacuation. Install manifold gauge set to condensing unit service valves. Take center hose of gauge set and attach to micron gauge. Connect 4th hose from micron gauge to inlet side of vacuum pump. Start vacuum pump, turn on micron gauge, and open both manifold valves to back seated position. Pull vacuum on system until micron gauge reads 500 microns or less. When achieved, close vacuum pump inlet valve and shut off vacuum pump. Monitor system pressure. Once 500 microns is attained, close manifold gauge set; remove micron gauge and 4th hose. If 500 microns cannot be achieved, inspect all refrigeration hoses and repeat steps 1 and 2.

Step 3 – Determine charge volume addition (over and above name plate volume). For factory matched systems, determine volumetric system charge adder based on line set and indoor coil calculations from outdoor unit Technical Guides. Line set volumes are determined using JCI'S / York's Comfort Cooling Piping Program available on UPGnet or piping application guide (247077-UAD-H-0209). Please note charge volume assumptions due to residual liquid in the gauge set hoses should be incorporated into the calculation. Here are examples of refrigeration hose charge volumes:

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1/4" *PLUS II*™	0.36	0.33	0.33	0.29	0.31	0.29	0.33
1/4" Heavy duty	0.34	0.31	0.32	0.27	0.30	0.28	0.32
3/8" *PLUS II*™	0.85	0.77	0.78	0.67	0.73	0.68	0.78
3/8" Heavy duty	0.85	0.77	0.78	0.67	0.73	0.68	0.78
1/2" Heavy duty	1.85	1.68	1.70	1.47	1.60	1.49	1.71
3/4" Heavy duty	3.89	3.53	3.58	3.09	3.37	3.13	3.60

Chart used with permission of Ritchie Engineering / Yellowjacket

The use of non AHRI matched coils is not recommended. If a 3rd party AHRI matched indoor coil is used, refer to the 3rd party manufacturer for charging information. In lieu of 3rd party AHRI matched manufacturer's charging information, use the factory matched coil charging information, recognizing that the charge will likely require further adjustment (charge addition or removal) during the charge verification process as defined in step 8. Document calculated charge adder on startup sheet in the installation packet.

Step 4 – Setup refrigerant Make sure cylinder contains sufficient refrigerant to complete the charge addition. Connect refrigerant cylinder to center hose on manifold set. Open refrigerant cylinder valve and purge hose to gauge manifold set. Place cylinder on scale oriented to charge in liquid phase and calibrate scale to "zero".

Step 5 – Introduce condenser charge to the system Allow vacuum to pull in refrigerant until calculated amount is reached. If this cannot be done wait till equalization occurs then open service valves to balance the rest of the charge while unit is running. Open liquid valve on unit and back seat. Open suction valve on unit and back seat. Replace both service valve caps, hand tight and then tighten with a wrench. Wait until the charge equalizes through the system (about 2 minutes).

Step 6 – Start system Obtain indoor wet bulb reading. This reading is a key input to the factory charging chart posted in the Installation manual and on the unit electrical cover, which is used to determine proper charge. Set the thermostat for cooling call and energize system. Observe system for nominal airflow and condensing unit operation. Let the unit stabilize for 10 minutes. Depending on indoor loading conditions, run time should be extended until indoor wet bulb is within the range of the charging chart (note: depending on the indoor temperature, this process could take up to several hours).

Step 7 – Introduce calculated charge volume addition (This is the amount of charge calculated in step 3). Slowly open suction manifold valve and monitor refrigerant scale until volumetric charge adder is met. Remember to add ounces for volume present in hoses to avoid overcharging the system. (On Pkg equip refer to charging chart in the installation manual).

Step 7b – Removal of contamination/acid from compressor burnout If the refrigerant system was opened as a result of a compressor burnout, additional steps are required to ensure absorption of contaminants left in the system. Run the system for 10 hours, then monitor the suction line drier pressure drop. If the pressure drop exceeds 3 psig, replace suction line filter drier and re-run the system for another 10 hours. If the pressure drop is less than 3 psig, remove the suction line drier, and perform an acid test. If the test shows no presence of acid, remove the suction filter dryer and close system. Re-establish system integrity by performing high pressure nitrogen leak check.

If the acid test shows acid still present in the system, replace suction line drier and re-run the system for another 10 hours. Repeat this process until acid is not present in the system.

Note that the suction filter drier can be run for more than 10 hours, but never leave the suction line drier in the system for over 50 hours of operation as this could lead to further contamination and compressor failure.

Step 8 – Validate charge value is correct and system is operating properly Continue to monitor the system until stabilized, typically 10-15 minutes. Please refer to the charging charts on the condensing unit to determine proper subcooling (for TXV applications) or superheat (for orifice applications). The charts are based on outdoor ambient conditions. If such information is not available in the Installation manual or the electrical cover, please contact Unitary Products Tech Services at 877-874-7378.

The subcooling and superheat charts on Figures 1 and 2 are examples of how to validate the correct charge and make further fine-tuning adjustments, if necessary.

Step 9 – Record your data Record the total system charge line set length and date on inside panel. This should be done adjacent to wiring diagram. This will be useful for the next service technician. Document required startup & commissioning data in factory provided startup sheet.

Charging Procedure "D"
Package Units - New & Retrofit Installations

There should be no need to adjust refrigerant charge in a new packaged system. With new package installations, it is assumed the new system has proper charge amounts, is free of leaks, and that the system meets factory specifications.

Novice technicians sometimes incorrectly introduce additional refrigerant at startup to raise the suction pressure. Adding refrigerant charge should not be done in packaged systems unless there is a leak, as it will result in higher loading and head pressure lockouts particularly on warmer days. In the rare instance that the new unit exhibits a leak, proper detection, repair, and charging is required per section "C".

Follow factory specified startup and commissioning practices to ensure external and return static pressures and airflows are consistent with proper system operation. In situations where an adapter curb is used, pay attention to pressure drop as the adapter could restrict airflow, and cause the system to be starved for air resulting in abnormally low saturation temperatures. Adapter curbs must be well designed to eliminate pressure drop across them. If not meeting proper air flow and static pressures, re-evaluate airflow, system loading conditions, duct sizing, and adapter curb configuration, and remedy as necessary.

It is not a good practice to place gauges on a new package MicroChannel system due to its charge sensitivity. System capacity can be calculated without gauges. A pressure temperature chart along with good temperature sensing equipment is all that is needed to calculate system capacity during start up. ($Q = 4.5 \times CFM \times (H1 - H2)$)

Q= capacity
CFM is measured CFM
H1 = entering enthalpy
H2 = leaving enthalpy

For systems that display reduced capacity, gauges must be used to determine the charge as listed in the charging charts contained in the installation manual.

As described above, there should be no need to adjust refrigerant charge in a new packaged system.