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Prepared by:
Proctor Engineering Group, Ltd.
San Rafael, CA 94901
(415) 451-2480

Nevada Power Company
New Construction HVAC Program
Implementation Plan

Prepared for
Nevada Power Company
Electric Power Research Institute
And
Nevada Department of Business and Industry, State Energy Office

Final Report
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Contributors:
Tom Downey
John Proctor, P.E.
Michael Blasnik

Creators of CheckMe!®

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INTRODUCTION

A. Background

This implementation plan is based on a study performed for Nevada Power Company (NPC), the Electric Power Research Institute (EPRI) and the Nevada State Energy Office (NSEO) and on a series of HVAC pilot studies performed for Pacific Gas & Electric (the Appliance Doctor™ projects) conducted by Proctor Engineering Group (PEG) over the course of several years. All of these studies evaluated potential energy savings associated with correcting deficiencies in residential air conditioning system installations.

Information was gathered to determine the condition of HVAC system installations in NPC's service territory during on-site testing in Las Vegas, Nevada, in the summer of 1994. This study was designed to quantify the extent of any existing HVAC system installation problems, and to examine the level of improvement achievable through working directly with installation contractors.

While the study performed for NPC was relatively small in size (30 houses), the Appliance Doctor™ projects were adequately sized to confidently project the level of improvement achievable through working with the installation contractors (the largest Appliance Doctor™ project included over 2000 houses). The results of the NPC study can be found in the report "Assessment of HVAC Installations in New Homes in Nevada Power Company's Service Territory" dated February 1, 1995.

B. Background- Appliance Doctor™ Projects

The Appliance Doctor™ projects demonstrated that cost effective repairs to systems were possible on a retrofit basis. Common to all of the Appliance Doctor™ projects were four main elements; First, each study worked to quantify the magnitude and extent of the problems with the air conditioning system. Second, systems were repaired to reduce or eliminate problems. Third, systems were re-tested to determine the results of implemented repairs. Finally, results were metered to determine the true effect of these repairs. The Appliance Doctor™ projects are listed below:

1. Appliance Doctor™ Heat Pump Project, Auburn, California (Proctor et al. 1990).
2. Appliance Doctor™ Air Conditioner and Furnace Project, Fresno, California (Proctor 1991).
3. Appliance Doctor™ Pre-Production Test, Fresno, California (Jacobson et al. 1992).

4. The Model Energy Communities (MEC) Program, Antioch, California (Kinert et al. 1992).

C. Results Of The Nevada Power Company Study

Common problems were evident in most of the houses tested in the NPC study. Among the problems identified were:

- Excessive duct leakage
- Insufficient duct insulation
- Excessive air conditioner sizing
- Incorrect airflow across the indoor coil of the air conditioner
- Incorrect refrigerant charge

These problems are responsible for significant increases in energy usage and peak demand in the houses studied. The most common and significant air conditioning equipment and distribution system problems can be resolved through a comprehensive program of commissioning the HVAC systems at the time of installation.

NPC is experiencing large growth rates in their service territory and would like to see the improvements made at the time of installation, rather than incurring the increased cost of repairing systems on a retrofit basis. The improvements if performed at the time of installation become easier to make for the technicians working on the system since they have access to all components of the system during assembly.

Procedure Problems

In spite of the fact that professional personnel had recently installed the systems examined in the study, the vast majority of the systems had at least one major problem. The existing heating, ventilating and air conditioning (HVAC) contractor infrastructure has failed to identify or solve these problems. Problems associated with the existing building trades infrastructure include:

1. Use of least cost bidding in awarding of installation contracts. This practice leads to less than optimal installation practices to keep the installation costs down.
2. Failure to set compliance procedures that ensure proper installation of the HVAC equipment.
3. Failure to ensure proper installation and operation of the HVAC equipment through direct testing of performance.

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PROGRAM DESIGN SUMMARY

A. Goals

The NPC New Construction HVAC Program has been designed to produce verifiable space heating and cooling savings of up to 40%, as shown in Table 2-1.

Table 2-1
Estimated Program Impacts

Program Design Elements	kWh Savings	kW Saving
A. Restrict Duct Leakage to 75 CFM_{25}	14%	22%
B. Duct Leaks @ 75 & R-8 Duct Insulation	23%	33%
C. Correct AC Charge and Air Flow Rate	10%	9%
D. Duct Leaks @ 75, Correct Charge & Air Flow	24%	27%
E. Duct Leaks @ 75, R-8, Correct Charge & Air Flow	32%	37%
F. Correct Charge & Air Flow, EER 2 Higher	26%	25%
G. All of Above	44%	48%

The estimated savings presented in Table 2-1 assume that the air conditioners are sized as discussed in the HVAC Installation Assessment final report (units sized to ACCA Manual J, tuned to an average duty cycle of 1/1.35 @ design).
Specifically, the NPC New Construction HVAC Program is designed to achieve the following Nevada Power Company goals:

1. Reduce peak demand - this helps NPC avoid capital outlay for generation, transmission, and distribution (which helps keep rates affordable for NPC's residential customers).
2. Reduce consumer energy usage.
3. Enhance public perception of Nevada Power - NPC will be the customer's ally in assuring a quality installation.

These savings also help the environment by slowing the Greenhouse Effect (reducing the amount of carbon dioxide released during generation), reducing pollutants such as oxides of nitrogen and sulfur, and conserving resources used to produce electricity.

These goals can only be accomplished when the individuals who install HVAC systems are given comprehensive standards and procedures that lead them through the installation process helping to ensure systems are correctly installed. Adequate training and allowing time to complete the installation are essential, as is all personnel being held accountable for the proper installation of the systems.

B. System Summary

The goal of the NPC New Construction HVAC Program is to develop a system that ensures proper installation and operation of HVAC systems, and to positively impact the existing HVAC infrastructure. The pilot indicated that heating and cooling inefficiency exists in most installed units, and this can be remedied by a program that contains a series of installation procedures and commissioning techniques. Installation programs must be carefully monitored, however, to ensure success.

The comprehensive system put into place by the NPC New Construction HVAC Program should include marketing, incentives for the Builder and HVAC Contractor, training, inspection services, and management controls.

Marketing

NPC must develop an effective marketing and promotion campaign that will enlist builders' involvement. NPC must work with both Builders and HVAC Contractors to ensure the quality of installations meet the NPC goals.

Contracting

NPC must establish contracts that tie any incentive to measured performance of the systems installed.

Training

Basic classroom/laboratory training, followed by field experience and feedback must be provided to all personnel involved in the program. Personnel must be trained by experienced instructors to follow the procedures of the program, and to understand and perform the tests and installation techniques designated for on-site work.

Quality Assurance

A quality assurance system must be developed that provides feedback to not only the Builders and HVAC Contractors but also the installers performing the work. Inspections must be undertaken on a percentage of the units completed. Control over the HVAC Contractors work should be accomplished by issuing incentive authorization only for units that were properly completed.

C. Program Structure and Responsibilities

In this plan there are five entities:

1. Nevada Power Company
   Responsible for overall project management.
2. Project Consultant (Contracted Company)
   Responsible for program design revisions and training.
3. Program Inspectors (Contracted Company)
   Responsible for scheduling and completion of all inspection services and reporting of findings.
4. Builder
   Responsible for processing completed jobs with NPC.
5. HVAC Contractor
   Responsible for the quality of installations, testing and reporting of measured installation parameters.

Organizing the Delivery System

Program management will be provided by NPC. NPC's initial tasks will be to establish marketing plans, obtain Builder and HVAC Contractor participation and finalize the contracting process outlined in Appendix A of this implementation plan. Ongoing tasks will include program promotion within the community, processing of incentive payments and handling of the corrective action process when necessary.

NPC will require a project consultant with adequate technical ability to provide further program design assistance and training services. The consultant selected must possess staffing with extensive training experience and in depth knowledge of duct system sealing and testing procedures and air conditioner installation and testing procedures. This consultant will act as a technical liaison for NPC with the Builders and HVAC Contractors participating in the program. The consultant will provide periodic training sessions and an ongoing technical review service.

The inspection contractor will be required to provide trained experienced personnel capable of testing both duct system integrity and measuring air conditioner system parameters needed to assess the quality of the installation both in terms of air flow and level of charge.

The Builders and HVAC Contractors will be responsible to arrange for employed personnel to attend NPC sponsored training and completion of program documentation.

Success depends on creation and delivery of a technical service beyond that currently available. Training HVAC Contractors is critical to achieving success. In order to maintain quality the Program Inspectors must remain independent of the Builders and HVAC Contractors.

Service Delivery

Service delivered by the Technical Consultant, Inspection Contractor, Builder and HVAC Contractors are detailed in the Appendix A.

APPENDIX A: PROGRAM DESIGN

The standards presented here are intended for the use of contractors and sub-contractors in the Nevada Power Company (NPC) New Construction HVAC Program. There may be other phases of delivery to the program that are not covered in this manual. NPC maintains the right to modify and/or change the procedures and standards outlined in this implementation plan at their discretion.

I. Start-up Phase

Past experience has shown it necessary to start projects slowly before establishing full-scale implementation. All parties involved in the program will need time to become accustomed to the program design and accommodate the learning curve. Making adjustments to the format of a new program under the strain of a full production schedule can be very difficult for all involved. Allotting specific time for a start-up phase will make it much easier for adjustments to be made. The start up phase will also give all parties involved in the management of the program a chance to become familiar with their job responsibilities before the pressure of full production begins.

The start up phase of the program should begin with the full staff of management personnel in place, and only two or three Builders participating in the program. During this time any adjustments necessary will be made to the program. The production schedule of homes involved in the program should not be left to the discretion of the Builders. NPC will need to control the number of houses authorized for participation in the program to keep the management staff from becoming overburdened during the start up phase. At the end of approximately one month there will need to be a review period during which production will be halted. The management staff will make refinements to the program during this time and revise program documentation and procedures as needed. After this brief interim period full scale marketing and production can begin.

II. Program Structure and Responsibilities

A. Work Plan/Organization

In this plan there are five entities:

1. Nevada Power Company
   Responsible for overall project management.
2. Project Consultant (Contracted Company)
   Responsible for program design revisions and training.
3. Program Inspectors (Contracted Company)
   Responsible for scheduling and completion of all inspection services and reporting of findings.
4. Builder
   Responsible for processing completed jobs with NPC.
5. HVAC Contractor
   Responsible for the quality of installations, testing and reporting of measured installation parameters.

The following tables define the roles and responsibilities of the organizations involved in the program.

Table A-1
Marketing and Program Start-Up

TASK		Contracted Support		Installation Contractor	
	NPC	Consult	Inspect	Builder	HVAC
Update of program procedures and forms	√	√			
Design evaluation system	√				
Establish production benchmarks	√				
Develop Marketing Plan	√				
Develop Marketing Materials	√				
Direct marketing	√				
Set criteria for Contractor eligibility	√				
Prepare and execute contracts	√				
Distribute Implementation Plan	√				
Train all personnel	√	√			

Table A-2
Delivery of Services

TASK		Contracted Support		Installation Contractor	
	NPC	Consult	Inspect	Builder	HVAC
Scheduling of production				√	√
Supervision of field personnel					√
Crew safety assurance				√	√
Enforcement of Implementation Plan	√				
Provide technical assistance	√	√	√		

Table A-3
Program Management

TASK		Contracted Support		Installation Contractor	
	NPC	Consult	Inspect	Builder	HVAC
Invoicing of completed work				√	
Builder invoice approval	√				
Coordination of Inspection scheduling			√	√	
Maintain database	√				
Produce pass/fail reports		√	√		
Field data review and feedback		√			
Monitoring production systems	√				
Perform inspections/reporting			√		
Updating Implementation Plan	√	√			
Implement corrective action	√			√	√
Control program costs	√				
Perform periodic evaluation	√				

III. Marketing

The goal of marketing is to work with both Builders and HVAC Contractors to increase the quality of installations to meet the NPC goals. The most favorable marketing strategy is one that sells both the Builders and the customers (home buyers) on participating in the NPC program.

NPC's marketing department will need to design and implement a marketing strategy that will be effective from both the contractors and the home buyers perspective.

A. Securing Contractor Participation

The first goal of the marketing plan is to secure Builder participation. One suggestion is that NPC design a "sellers" package aimed at potential home buyers that will meet the needs of both NPC and the Builders. A marketing program designed by NPC that is available for use by participating Builders could help sell customers on the fact that they are ensured of getting a quality HVAC installation under this program could give participating Builders a marketing edge over their competitors.

Builder input in the final version of this marketing package is critical. It is suggested that NPC design a preliminary package that can be presented to interested Builders in a forum such as a focus group to obtain consensus from the Builders on the content and format of the marketing materials. Builder input needs to come from the population as a whole so that all Builders involved in the program feel that they had an opportunity to express their opinions and have their needs met. For this reason it is suggested that this Builder input take place after the start up phase of the program is completed. The start up phase of the program will be limited in the number of Builders participating and changes to the program due to lessons learned in the start up phase could change the scope of the program and therefore force another round of changes to the marketing materials.

B. Promotion for Prospective Home buyers

Experience indicates that marketing pieces should be direct and concise. Customers respond to a straight-forward program description with a list of benefits of participation included. In the marketing piece, home buyers should be informed that their home has been thoroughly tested to ensure that it meets NPC's stringent criteria for quality of installation. The marketing piece should stress benefits of the program to potential home buyers:

1. The increased comfort associated with homes built by participating Builders: Producing and delivering the cooling to conditioned space rather than allowing their cooling dollars to escape outdoors.
2. The benefits of an efficiently operating system: Cutting cooling bills by up to 40% over comparable homes built by Builders not participating in the program.
3. The increased life of the equipment installed in their home: Avoid costly repairs and early equipment failure due to improper installations.
4. The assurance that their system is installed correctly: The air conditioning systems are commissioned to ensure they meet the stringent installation criteria established by the program to ensure quality installations.

C. Contractor Incentives

An equitable incentive structure must be set that will persuade Builders to participate in the program. The level of incentive needs to be set based on NPC's benefit from ensuring systems are correctly installed (reducing NPC's capacity and T&D requirements). Many options are available for this incentive structuring, ranging from direct monetary incentives to either the HVAC Contractor or Builder based on verified compliance with the installation standards to indirect incentives such as providing "free" inspection services for Builders to assist them in being sure they got the quality installation they paid for.

The recommended approach is to provide the Builder with a service (free promotion materials and inspection services) and provide the HVAC Contractor with a monetary incentive that will help cover their direct expenses associated with changes to their current practices. Rather than point fingers at HVAC Contractors currently completing inadequate installations, NPC should work with the HVAC Contractors to bring about the needed changes. HVAC Contractors will realize cost increases due to the proposed changes and NPC should demonstrate their willingness to help offset these cost increases by offering a monetary incentive to the installing HVAC Contractor. This incentive will:

- Insure that NPC obtains contractor participation.
- Help offset cost increases that the HVAC Contractor might realize.
- Avoid cost increases for the Builder and the home buyer.

The actual amount of the incentive will need to be determined by NPC, based on their avoided costs. The report "Assessment of the Quality of HVAC Installations in Newly Built Homes in Nevada Power Company's Service Territory" dated February 1, 1995 details the projected costs to the HVAC Contractor and the benefits realized by NPC.

IV. Installers, Equipment, and Materials Specifications

NPC requires that HVAC Contractors follow the format for production that are outlined in this manual. Contractors can submit proposals for a delivery of service that make adjustments to the structure of the crews and/or delivery of services. NPC reserves the right to accept or reject any proposal for changes based on their judgment as to the suitability of the proposed changes.

A. Licensing

All Installers responsible for installation of duct and air conditioning systems under this program must attend a short introductory training sponsored by NPC. The purpose of the training is to introduce the new methodologies, promote consistency

in application of the new methodologies and insure the durability requirements of the program are understood by everyone.

All HVAC Technicians involved in the air conditioner installations must be of journeyman level and either hold a HVAC license or work directly for a company with such a license. All work performed under the Program must be performed by HVAC Contractors with the appropriate license(s).

B. Attrition and Replacements

The training investment by NPC and the Contractors is quite substantial. It is necessary that contractors hire personnel with the reasonable expectation that they will successfully complete all training and be able to utilize the technical equipment in the program with eventual expertise.

Individuals will need to be trained periodically throughout the course of this program. When the need arises, the HVAC Contractor may apply to have additional installers trained in one of NPC's regularly scheduled training sessions.

In order to minimize loss due to installer attrition and the costs incurred for training, it is recommended that each HVAC Contractor have additional individuals trained. In order to ensure the alternate technician does not forget what they have learned in training it is suggested that they periodically be rotated into installation production.

V. Training

Each individual working in the program shall be trained through the NPC sanctioned training seminar. No individual will be allowed to work in the program until they have successfully completed the NPC prescribed training. Each technician must attend all portions of the training. NPC will schedule periodic training sessions to accommodate HVAC Contractor and installer attrition.

Adequate training involves providing both Basic Training (classroom and laboratory) by experienced personnel, and field experience with feedback on actual units.

A. Basic Training

Each person responsible for duct and air conditioning system installation must complete a one day training session.

Duct System Installers. The basic training of the Duct Installers is provided to ensure that the installers will understand their responsibilities and will be able to:

1. Install duct systems using approved materials in a manner that meets the durability requirements set by NPC.
2. Test installations to determine if they meet the program performance requirements.

Basic Training for the Duct Installer will consist of:

1. One half day in the classroom on the requirements of the program as presented in Sections VII and VII of this Appendix. This will include duct leakage testing, duct leakage test equipment usage, duct sealing techniques, pressure and flow measurements, etc. Program procedures will be covered in detail.
2. One half day in the field as a group with an on-site Trainer to demonstrate the sealing and duct leakage testing methodology presented in the classroom.

Air Conditioning System Installers. The basic training of the HVAC Installers is provided to ensure that the installers will understand their responsibilities and will be able to:

1. Install Air conditioners using methods and equipment that meet the requirements set by NPC.
2. Test installations to determine if they meet the program performance requirements.

Basic Training for the HVAC Installers will consist of:

1. One half day in the classroom on the requirements of the program as presented in Section IX of this Appendix. This will include HVAC system basics, air flow measurement, evacuation procedures, charging procedures, etc. Program procedures will be covered in detail.
2. One half day in the field as a group with an on-site Trainer to demonstrate the air flow testing, evacuation and charging methodology presented in the classroom.

Inspectors. The basic training of the Inspectors is provided to ensure that the Inspectors will understand their responsibilities and will be able to:

1. Examine installations to ensure they meet the programs installation and durability requirements.
2. Test installations to determine if they meet the program performance requirements.

Basic Training for the Inspector will consist of:

1. One day in the classroom on the requirements of the program as presented in Sections VI, VII, VIII, and IX of this Appendix. This will include covering all materials presented in both the duct installer and air conditioning installer trainings and program criteria for compliance with the installation standards.
2. One day in the field as a group with an on-site Trainer to demonstrate the inspection and testing methodologies presented in the classroom.

VI. Duct Sizing

The study, Assessment of the Quality of HVAC Installations in Newly Built Homes in Nevada Power Company's Service Territory found that the average house in the study had deficient air flow through the indoor coil when compared to both the manufacturers suggested air flow (400 CFM/Ton) and the ACCA Manual D calculation.

These standards provide the basic criteria to be met in the sizing of duct systems installed under the NPC New Construction HVAC Program.

The purpose of these guidelines is to ensure adequate duct system sizing for the air conditioning equipment installed. The ducts are of primary importance because they are the air leakage points of highest pressure differential within the building at the time of peak electrical energy consumption.

A. Procedures

Air conditioners can only provide the correct amount of air flow and cooling when the duct system is correctly designed. To avoid air flow problems in units installed under the NPC New Construction HVAC Program, the following standards have been established:

All duct systems must be designed according to ACCA Manual D. Specifically:

1. System air flow requirements shall be determined as outlined in Section 5 of ACCA Manual D.
2. All systems shall have at least one supply duct run for each 4,000 Btu/hr of rated capacity of the cooling equipment installed.
3. All systems shall have one return duct run, equipped with a filter grill, for every 30,000 Btu/hr of rated capacity of the cooling equipment installed.
4. Duct systems shall be sized to minimize design static pressures and afford adequate sizing and to overcome additional static pressure caused by installer deviation from the design specifications. To ensure the system duct sizing is adequate to allow for these deviations the total design static pressure calculated in Section 5 of ACCA Manual D shall be reduced by 20% before the selection of the duct system is completed (thus lowering available static pressure on both the supply and return side by 20%).

VII. Duct Sealing

These standards provide the basic criteria to be met in sealing the duct systems installed under the NPC New Construction HVAC Program.

All work shall follow the procedure delineated here and contained in the NPC New Construction Duct Forms. Systems are not considered complete until the forms are filled out completely and correctly.

The purpose of this work is to reduce air leakage losses from ducts. The ducts are of primary importance because they are the air leakage points of highest pressure differential at the time of peak electrical energy consumption.

A. Procedures

The NPC New Construction Duct Form guides the installer through tests of the duct leakage to insure their completed job has met the leakage criteria of the program. Duct leakage testing is to be completed at the time of duct system installation (before installation of dry wall or other obstacles that will prohibit access to the individual duct system components).

All duct system components must be installed and in place (with the exception of the return grill and supply registers), prior to the duct leakage testing procedure being performed. All air handler doors and covers must be in place.

The duct leakage tests shall be performed with:

1. All registers, except the return used for the duct leakage test equipment must be tightly sealed against air flow.
2. The duct leakage test equipment attached to the largest least restricted return (the transition from the duct leakage test equipment to the return system must be tightly sealed).
3. Any filters must be removed from the system.
4. The duct system pressure reference point located in the supply side boot closest to the supply plenum.

The duct system is pressurized to 25 pascals with duct leakage test equipment and the flow through the duct leakage test equipment is determined through use of the procedures supplied with the duct leakage test equipment.

This test gives an indication of the amount of total duct leakage and the adequacy of the sealing job completed by the installers.

B. Performance Standards

The goal of the NPC New Construction HVAC Program is to reduce the duct leakage as much as possible. The ultimate goal of the program is to achieve duct systems with no leakage (all conditioned air comes from and is delivered to the house).

Specifically the duct performance standards are:

1. The maximum amount of duct leakage allowable is 75 CFM at 25 Pascals of duct pressure per system.
2. The duct system shall be installed in accordance with the Manual D design parameters used to ensure unrestricted air flow of the system and avoid excessive static pressure build up on either the return or supply side of the system.

In addition flexible duct runs shall be installed per SMACNA standards, so that:

1. Run lengths are properly sized to avoid compression or stretching
2. Runs are made as straight as possible avoiding tight bends
3. Runs are correctly supported to avoid excessive sags between supports
4. Ducts are not crushed or diameter reduced for sake of fit

C. Prescriptive Measures

All duct systems must be installed in accordance with the specifications submitted for use in Manual D design considerations. In addition, all duct systems must meet the following criteria:

1. All duct system components shall be constructed of approved sheet metal, fibrous glass duct board, or flexible metal or vinyl coated helix core ducts. No building cavity chase ways are allowed as a means of conducting air to or from conditioned space (i.e. panned floor joist return runs).
2. Duct board, sheet metal, or other NPC approved blocking material shall be used to enclose any air handler support platforms that are used for returns. If duct board is used the foil clad side must face the air handler to create an adequate air barrier. All materials must be applied and sealed with fibrous glass mesh embedded with mastic in a manner that creates a permanent air tight seal from the grill to the to the air handler.
3. All boot to drywall (or flooring) seams must be sealed at the time of register/grill installation. All perimeter seams must be 100% sealed with mastic or other NPC approved material.
4. If toe kick space registers are used an enclosure must be added to the base of the cabinet that directs all delivered air to the register.
5. Package units mounted to a roof jack plenum assembly must have the entire perimeter of the plenum/package unit connection sealed with a fibrous glass mesh embedded with a weather resistant mastic rated for outdoor use.

6. Package units with a single connecting plenum with a supply/return divider panel must be sealed. The separating panel must be sealed with fibrous glass mesh embedded with mastic.
7. All evaporator coil enclosures must be fitted with an access panel that allows easy access to the incoming air side of the evaporator coil for future maintenance. This access panel must have adequate perimeter gasketing to seal the panel from leakage or be sealed with mastic.
8. All attic mounted air handlers must be equipped with filter grilles that allow the homeowner to access the filter from the conditioned space of their home. Filters may not be located where attic access is required for changing or cleaning them.

D. Durability Requirements

Each joint sealed shall be connected and sealed so that the life expectancy shall exceed fifteen years. All seams and joints within the duct system must be sealed with mastic or fibrous glass mesh embedded with mastic. Duct system connections must be made in the following manner:

Mastic Application.

1. All mastic must be applied in accordance with the manufacturers recommendations (the mastic may not be diluted by any substance).
2. Mastic applications must be placed over the entire joint or seam and overlap all joints or seams by a minimum of 1.5".
3. When fibrous glass mesh is used it must:
   - Have a minimum width of 2".
   - Be placed over the entire joint or seam and overlap all joints or seams by a minimum of 1".
   - Have mastic applied in a manner that it becomes thoroughly embedded in the mesh.
   - Mastic must overlap the mesh by a minimum of 1.5".
4. All mastic used must have a solids content of greater than 50%, a flame spread rating of not more than 25 and a smoke development rating of not more than 50.

Duct Board & Pressure Sensitive Tape Application.

Pressure sensitive tape is allowed only on the joints of factory assembled duct board plenum assemblies. Pressure sensitive tape can only be used on duct board to duct board joints and can not be used to seal any materials other than duct board. No other joints (i.e. duct board plenum to take off collar) may be sealed with pressure sensitive tape. No field assembly of pressure sensitive tape connected joints is allowed by the program.

1. Duct board can only be used for return and supply plenums. Duct board triangular junction boxes shall not be allowed in the program. All branch duct connections shall be made with the use of rigid sheet metal wyes.
2. All pressure sensitive tape used on plenums installed in this program must be UL 181A listed and shall bear the UL 181A-P mark.
3. All pressure sensitive tape must be installed to meet the manufacturers recommendations and the following:
   - Have a minimum width of 2.5".
   - Have a minimum seam overlap of 1".
   - Be applied to a clean dry surface.
   - Be applied with a plastic squeegee and sufficient pressure to ensure a good bond.

Metal Ducts

1. All metal duct fittings must be connected using three sheet metal screws at every joint (per UMC).
2. All crimp connection seams and joints must be sealed using fibrous glass mesh embedded with mastic.
3. All other joints (i.e. elbow swivel joints, factory wye connections and longitudinal snap lock seams) must be sealed with mastic.

Flexible Ducts

1. Plastic flex ducts must be connected by:
   - Securing the inner liner to the metal collar using panduit straps tightened with a tensioning tool.
   - The duct inner liner must be sealed to collar using fibrous glass mesh embedded with mastic.
   - The outer vapor barrier must be secured to the metal collar using a panduit strap tightened with a tensioning tool.
2. Duct system runs must be supported per the manufacturers specifications or as outlined in Uniform Mechanical Code (UMC) and local building codes. Great care should be taken to ensure trunk and branch duct runs do not sag between supports and for flexible duct systems that the flex duct is fully extended.
3. Any penetrations of duct board plenums must be sealed with mastic and fibrous glass mesh at the duct board to metal collar connection.

E. Equipment Required

1. Duct leakage test equipment capable of meeting the following specifications:
   - Fan flow calibration specifications that meet ASTM standard E779-87.
   - Can accurately measure flows as low as 30CFM.
2. Digital manometer capable of meeting the following specifications:
   - Has resolution of 0.1 Pascals and a minimum accuracy of +/- 3%.
   - Has a range of 0 - 1000 Pascals.
   - Contains an auto zeroing feature.
   - Has time averaging feature for use in windy conditions.

Calibration. Any instrument used for duct leakage testing which requires calibration must be periodically calibrated according to the timelines and calibration procedures as outlined by the manufacturer.

VIII. Duct Insulation

These standards provide the basic criteria to be met in insulating the duct systems installed under the NPC New Construction HVAC Program.

The purpose of this work is to reduce heat gain and conductive losses from ducts. The ducts are of primary importance because they are the point of greatest temperature differential at the time of peak electrical energy consumption.

A. Prescriptive Standards

All duct systems installed must meet a minimum R-value of R-8 for the entire duct system located in unconditioned space (i.e. attics, garages, etc.).

The following are the only allowable exceptions to the R-8 duct insulation standard:

1. Duct system components located within the conditioned space do not have to meet the R-8 standard, but must be R-4.2 or better.
2. Portions of the duct system constructed entirely of duct board (i.e. duct board plenums) are allowed to have an R-value of R-6.5, or better.

B. Durability Requirements

Manufacturers documentation of R-value must be supplied to NPC by each HVAC Contractor. All duct insulation must be installed in the following manner to ensure its continued performance over the lifetime of the structure:

1. All duct insulation will be installed per the manufacturers specifications. Care shall be taken to ensure the insulation is not compressed beyond the manufacturers allowed compression rate.

2. All duct systems must have an installed R-value rated at a 75°F mean temperature. This R-value is to be based on the value of the duct insulation itself. No value can be added for special vapor barriers unless verified by an independent laboratory and approved by NPC.
3. All rigid duct systems shall have a minimum of R-8 insulation. The rating for insulation shall be the rated installed R-value not the out of package rated R-value.

IX. Air Conditioner Installation

The purpose of this work is to maintain the efficiency of the installed air conditioner by insuring that the proper amount of air is flowing through both indoor and outdoor coils, and that the refrigerant charge is to manufacturers specification.

All installation work shall follow the manufacturers recommended procedures and the procedures delineated here and contained in the NPC Air Conditioner Installation Form. Homes are not considered complete until the form is filled out completely and correctly.

A. Procedures

The NPC Air Conditioner Installation Form guides the installer through tests of the air conditioners performance to ensure their completed job has met the installation criteria of the program. AIR CONDITIONER PERFORMANCE TESTING IS TO BE COMPLETED AT THE TIME OF REGISTER/GRILL INSTALLATION. All system components must be installed and in place prior to the Air conditioner performance testing procedure being performed (testing the system as it will perform for the customer).

The air conditioner performance tests guide the HVAC Contractor through the following:

1. Tests of the air flow through the indoor coil. This test confirms that the actual air flow through the indoor coil meets the manufacturers specified air flow rate. For the purpose of the NPC New Construction HVAC Program this flow rate shall be 400 CFM/Ton (wet coil state) unless the HVAC Contractor supplies NPC with manufacturers data that indicates a different air flow rate in the wet coil state. The air flow test shall be performed as follows:
   - All supply registers and return grilles shall be in place and any dampers fully opened.
   - A clean filter shall be in place at its normal location.
   - The air conditioner shall be run for a minimum of fifteen minutes before the flow rate is tested (to allow the indoor coil to become wet).
   - The air flow through the return grilles shall be measured with a calibrated flow hood and summed to determine the total flow rate through the return grilles.

Only calibrated **flow hoods** with an accuracy of +/- 3% or better that read in CFM directly are allowed for air flow measurement. No type of anemometer, velometer, manometer or other device that requires computation of grill/duct free area are allowed for air flow measurement.

- CFM/Ton will be calculated using the exact ARI rated **tonnage** of the air conditioning unit (i.e. 28,500 Btu/hr divided by 12,000 equals 2.37 Tons not 2 tons or 2.5 tons).

2. Cooling capacity and efficiency tests shall be performed to determine if the unit is performing reasonably close to its rated design capacity as specified by the manufacturer. Capacity and efficiency tests will be performed after the air flow test is completed. The measured operating capacity of the unit will be based on sensible capacity only since the ASHRAE and ACCA design conditions for Las Vegas (0 grains moisture difference) does not consider there to be any latent load of reasonable proportion. In addition the house is unoccupied so there will be no internal latent load. The capacity and efficiency tests test shall be performed as follows:
   - All supply registers and return grilles shall be in place and any dampers fully opened.
   - A clean filter shall be in place at its normal location.
   - The air conditioner shall be run for a minimum of fifteen minutes before the actual flow rate is tested (to allow the refrigerant system to reach equilibrium).
   - Dry bulb temperatures will be measured in the supply and return **plenums** in a location representative of the true temperature differential across the indoor coil.

     A calibrated digital thermometer must be used to measure the dry bulb temperatures.
   - The systems input will be measured using NPC's kWh meter with all other electrical circuits to the house turned off. (An alternative is the use of a watt meter on the air conditioner circuit that measures input for both the indoor and outdoor components of the air conditioner).
   - The systems operating sensible capacity and EER will be calculated using the measured parameters outlined above.

B. Performance Standards

The goal of the NPC New Construction HVAC Program is to ensure that the air conditioning systems installed under the program are operating at the capacity and efficiency as designed and published by the manufacturer. In order to achieve this goal NPC has established the following standards:

Air Flow Through the Indoor Coil. Major air conditioning manufacturers recommend an air flow rate through the indoor coil of at least 400 CFM/Ton. In hot dry climates such as Las Vegas the air flow rate can easily be set at a higher rate due

to the negligible latent capacity required of the equipment without causing customer discomfort. Lower air flow rates result in lowered capacity of the equipment. The air flow rate measured under this program is the highest that the system will ever experience (over time coils, blowers, filters, etc. will become dirty and reduce the air flow). Because of this, NPC has set it's standards as follows:

The measured CFM/Ton must be at least 400 CFM/Ton (wet coil).

1. If the measured CFM/Ton is below the standard minimum of 400 CFM/Ton, the HVAC Contractor will measure the supply and return system static pressures. Based on these pressures the HVAC Contractor will implement the repairs to the duct system necessary to obtain 400 CFM/Ton (wet coil).
2. If any air flow repair work outlined in 1) above is completed the air flow test procedure must be repeated to obtain accurate air flow information for use in the capacity and EER calculations.

Cooling Capacity and EER. Incorrect system air flow and charge can lead to lowered operating capacity and efficiency. The systems measured operating sensible capacity and EER shall be within ± 5% of the calculated sensible capacity and EER, based on the manufacturers data, adjusted for indoor and outdoor conditions measured during the tests. If the systems operating sensible capacity and EER do not meet this standard, further diagnostic tests must be performed by the HVAC Contractor to locate the cause and correct the problem with the system.

C. Prescriptive Measures

The goal of the NPC New Construction HVAC Program is to ensure that the air conditioning systems installed under the program are properly sized and installed according to the manufacturers installation instructions and the standards outlined in this implementation plan. In order to achieve this goal NPC has established the following standards:

Sizing. Sizing of the cooling equipment is one of the most critical factors affecting home owner comfort and conditioning costs. The study Assessment of the Quality of HVAC Installations in Newly Built Homes in Nevada Power Company's Service Territory found that the average house in the study was oversized by 33% over the ACCA Manual J load calculation. ACCA Manual J suggests that cooling equipment capacity not exceed design by more than 15%. Oversized units tend to short cycle which leads to lowered operating efficiency and customer discomfort. In addition oversized equipment costs more to install not only because of the increased cooling unit costs but also because of the increased cost due to duct system sizing to meet the needs of the larger unit.

House cooling loads must be calculated based on ACCA Manual J or other NPC approved load calculation methodologies. In addition, once the cooling load of the house has been determined equipment shall be selected based on the following:

1. Total capacity of the equipment at indoor conditions of 75°F dry bulb temperature and the wet bulb temperature at which the total and sensible capacities become identical.
2. At no time shall equipment with a sensible capacity greater than the Manual J calculated load be installed in the house.

The reasoning for this selection methodology is that there will be no appreciable latent load on the equipment the majority of it's run time. Further the conditions at which the equipment will be called upon to produce the most cooling occurs during periods of hot dry conditions, therefore diminishing the need for latent capacity.

HVAC Contractors must supply NPC with the manufacturers performance data for each type of air conditioner they will be installing under this program.

Indoor Coil. All indoor coils must be installed in a manner which assures they are easily accessible for future cleaning. All coil cabinet joints and penetrations must be sealed to prevent air leakage, including the refrigerant line penetrations of the evaporator coil cabinet. All condensate lines must contain a trap and be properly pitched away from the coil and terminated at an open drain or outside.

Outdoor Unit Installation. All outdoor units shall be in accordance with the manufacturers specifications and local codes. In addition, outdoor units shall be installed as follows:

1. Installed on pads or stringers as suggested by the manufacturer.
2. Located to follow the manufacturers specifications for minimum clearances for louvered side air intakes and service valve access.
3. Located to prevent air re-circulation through the outdoor coil. The unit shall not be installed under any structure that can cause re-circulation.
4. When feasible the outdoor unit shall be installed on a side of the house that does not receive direct sunlight in the afternoon.

Refrigerant Lines. Excess refrigerant lineset length not only costs HVAC Contractors (and therefore the home buyer) more money but they also present the possibility of oil accumulation in the lineset that can lead to excess wear on the compressor. All refrigerant lines must be sized, installed and brazed in accordance with the manufacturers specifications and/or the specifications outlined here, whichever are more stringent. Refrigerant lines must be installed as follows:

1. All linesets shall be correctly sized to the manufacturers recommended diameter and cut to the correct length for the installation (no coiling of excess line) with a tubing cutter or other manufacturer approved method.
2. Soft copper tubing if bent, must be bent with the use of a spring type bender or a mechanical tube bender to prevent kinking and/or the weakening of the tubing.
3. All lineset connections must be brazed with the use of dry nitrogen within the lineset to prevent oxidation and scaling in the pipes interior during brazing. The nitrogen must be kept in the tubing throughout the entire brazing process.

4. Heat sink material must be used during brazing to prevent damage to heat susceptible components in the refrigerant system.
5. The entire length of the suction line must be insulated to prevent condensation.

Evacuation. For an air conditioning system to function properly it must be free of contamination and charged properly. Evacuation removes air and moisture (non-condensables) from the system. All line sets and indoor coil assemblies must be evacuated for split system air conditioners.

In order to perform the evacuation procedure correctly installers need:

1. A leak free manifold and gauge set, air tight enough to hold a vacuum of 100 microns.
2. A two stage vacuum pump capable of drawing a vacuum of 100 microns (a vacuum pump with clean oil free of contamination).
3. A vacuum pump isolation assembly (valve tree) for isolating the vacuum pump from the lineset while allowing the micron gauge to measure the amount of vacuum in the lineset.
4. A calibrated micron gauge (vacuum indicator) capable of measuring down to 50 microns. Thermistor type micron gauges are recommended for their superior accuracy in measurement.

To achieve proper evacuation NPC requires use of the following evacuation method:

1. Evacuate the system to 300 microns.
2. Isolate the vacuum pump from the system. Isolated system pressure must be 300 microns or less.
3. Allow system to sit for five minutes. System pressure must not rise above 500 microns.

Evacuating the system to 300 microns will ensure that all air and the majority of the moisture has been removed from the system. Letting it sit for five minutes will confirm that all the air and the majority of the moisture has been removed from the system. If the system rises above 500 microns during the five minute waiting period there is either a leak or moisture in the system. Continued evacuation or location and repair of a leak must be made until the system meets the evacuation requirements listed in 1 through 3 above.

Refrigerant Charge. The proper charge of the installed air conditioner is of utmost importance. Failure to strictly adhere to the manufacturers recommended charging procedures and the procedures outlined in this implementation plan can result in numerous problems not only for the homeowner but also the builder, the HVAC Contractor installing the air conditioner, NPC, and the air conditioning manufacturers.

Improper system charge can lead to:

- Reduced comfort and higher utility bills for the NPC customer.
- Shortened life of the equipment.
- Nuisance complaints for the Builder.
- Reduced profits for the installing HVAC Contractor.
- Increased warranty costs for the manufacturers.

To ensure that all air conditioning systems are operating at their designed capacity and efficiency NPC requires the following charging procedure:

1. Package unit air conditioners come from the factory pre-charged and require no adjustment.
2. Split system air conditioners come from the factory already charged or with the proper charge indicated on the name plate. The manufacturer supplies information to determine that charge will be sufficient for the application based on lineset length. It is the responsibility of the installing HVAC Contractor to ensure that the charge is correct for each air conditioner. HVAC Contractors are responsible for adjusting charge based on lineset lengths less than or greater than the lineset that the unit charge is rated for. NPC requires that all installing Contractors:
   - Supply NPC with information on the lineset length and diameters installed with the system.
   - Supply NPC with the manufacturers information on charge adjustment (by weight) for all applicable lineset diameters.
   - Weigh in or remove the correct amount of refrigerant based on the manufacturers recommended charge adjustment per foot determined by lineset diameters.
   - Supply NPC with the amount of refrigerant charge adjustment for every system and the calculations used to determine the charge adjustment.

D. Equipment Required

Each air conditioning technician performing installations and/or testing of installed systems must have the following equipment:

- Beaded probe thermocouples (low mass thermocouples).
- Charging cylinder or scale capable of determining the charge added or removed from the system.
- Digital thermometer with differential capabilities and a resolution of .2° F.
- Dry nitrogen for brazing.
- Electronic refrigerant leak detector.
- Micron gauge.
- Refrigerant recovery equipment and refillable container to store captured R-22.

- Stopwatch and calculator.
- Two stage vacuum pump (with clean oil).
- Valve core replacement tool that allows replacement without loss of refrigerant.

X. Technical Process Review

A. Form Review

The forms used by the installation personnel embody the step-by-step procedures. Installation personnel use these step-by-step procedures to test the critical parameters of the system. These parameters include measured duct leakage, duct location, rated and measured air conditioner efficiency, and many others. Upon completing work at any site, test forms will be returned to NPC, entered into a comprehensive data base, and checked for program specification compliance.

NPC will review the data reported by the HVAC Contractors. Any systems that fail to meet the programs criteria for installation will be returned to the installing HVAC Contractor for correction. Any job which requires follow up work by the contractor must be completed as promptly as possible after receipt of the NPC report to ensure access to system components (i.e. duct system) and to minimize work delays of the other trades.

Categorization Criteria. A unit is not considered completed until NPC is reasonably certain that it will meet the standards of the program.

An individual unit has successfully completed Form Review if:

1. All the forms' blanks are filled in with understandable data.
2. The form indicates that the work has met all the performance and prescriptive criteria in this Implementation Plan.

An individual unit will be returned to the contractor for additional work if:

1. There is missing or incorrect information on the form.
2. The form indicates that the work does not meet the performance or prescriptive criteria in the Implementation Plan.

B. Inspections

All inspections shall follow the procedure delineated here and contained in the NPC Inspection Form.

The following standards provide the basic criteria to be achieved in inspections.

Purpose of Inspection. The issues that the Inspector must address in Inspection are:

1. Performance: Upon the completion of the installation what are the leakage numbers for the ducts, what is the air flow through the indoor coil, what is the measured capacity of the air conditioner, etc.
2. Durability: Are the applied materials durable and applied in a way that does not create safety problems?

The information gathered in inspections also has a critical role in assisting everyone in the program to become more competent. Inspection information must be shared with the personnel involved rapidly for them to learn from the feedback.

Types of Inspections. Post-inspection consists of verifying the final information turned into NPC on the forms from the Contractors. This will include, but is not limited to:

1. Duct leakage test.
2. Inspection of the sealing methods.
3. Inspection of critical repairs of platform.
4. Inspection of random register and grill boots.
5. Capacity test of the air conditioner.
6. EER test of the air conditioner.
7. Inspection of duct insulation.

In addition to inspections, there are on-site verifications of work in progress by the installers.

An on-site verification will include:

1. Witnessing of installation testing procedures.
2. Inspection of the installation methods.
3. Inspection of installation technician equipment (to ensure compliance).

Inspection Guidelines. The Inspector will post-inspect the first five production units done by any contractor. This will apply whenever there is a personnel change on any installation crew. This early inspection and feedback process will ensure the installers understand the program standards and will correct any deficiencies.

The Inspector will post-inspect ten percent of the production units. The inspection contractor may complete up to half of the required inspections with on-site verifications. All post and on-site inspections shall have an inspection form completed by the Inspector. All inspections must take place within five working days of referral by NPC.

Pass/Fail Criteria. The houses will be judged as completed based on whether the HVAC Contractor has complied with the criteria stated in the Implementation Plan.

A unit is not considered completed until NPC is reasonably certain that it will meet the standards of the program.

A unit has successfully completed inspection if:

1. The information on the forms is in substantial agreement (±5%) with the measurements made by the Inspector.
2. The work meets all the performance and prescriptive criteria in the Implementation Plan.

A unit will not pass inspection if:

1. There is incorrect information on the form.
2. The work does not meet the performance or prescriptive criteria in this Implementation Plan.