Title
China Energy Efficiency Round Robin Testing Results for Room Air Conditioners

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Publication Date
2010-06-15

Peer reviewed

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June 2010

This work was supported by the Ministry of Economy Trade and Industry and the Institute of Energy Economics, Japan and the Collaborative Labeling and Appliance Standards Program through the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

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I.1 BACKGROUND

I.1.1 China's Energy Constraint Problem and the Need to Improve the Energy Efficiency of Energy Consuming Products

In recent years China's energy consumption has increased rapidly. The problem of high energy consumption intensity and low energy utilization efficiency is serious, and the contradiction between economic development and energy and environmental resources has become increasingly acute, making energy conservation and consumption reduction an important society-wide concern. At the same time, global climate change has and will continue to have profound impacts on human survival and development, and is another major challenge to all countries. In order to accelerate China's energy conservation and emission reduction work, the National Leading Group to Address Climate Change, Energy Conservation and Emission Reduction was founded with Premier Wen Jiabao as the head, and the "Comprehensive Work Program of Energy Conservation and Emission Reduction" and "China's National Program of Addressing Climate Change " were issued, under which China's energy conservation and emission reduction work has been fully deployed. Efforts to promote energy efficiency have been further strengthened in all levels of government, and various policies and measures have progressively been issued and implemented. In addition, based on China's experience with implementing energy-saving priority strategies over the past 20+ years, our government established a goal of a 20% decrease in energy consumption per unit GDP in the "Eleventh Five-year Development Plan. Furthermore, in November 2009, in order to support global greenhouse gas emission reduction activities and promote China's low carbon economic development, the government established a further 40-50% reduction in energy consumption per unit GDP by 2020 compared to the year 2005.

Improving energy utilization efficiency by scientific and technological progress will undoubtedly play an important role in achieving the above stated objectives. The improvement of energy efficiency of energy consuming products has always been an important component of all countries' energy strategies. As we all know, a very large amount of total energy consumption is due to energy consuming products and equipment, which account for about 50% of China's total energy consumption. However, the current average energy utilization efficiency of this sector is only about 60%, 10 percent lower than the international advanced level. Therefore, China's energy consuming products and equipment sector holds great energy-saving potential. On the other hand, the energy supplied to these products is mainly from fossil fuel combustion, a major source of greenhouse gas (GHG) emissions. Therefore, improving the energy efficiency and augmenting the market

share of market-dominant energy consuming products is of significant importance to achieving China's energy saving and emission reduction target and is an effective means to deal with energy and environmental constraints and climate change issues.
Main energy consuming products generally include widely-used home appliances, industrial equipment, office equipment, transportation vehicles, etc. China is one of the major manufacturers and exporters of energy end-using products such as air-conditioners, refrigerators, televisions, etc. Their overall energy efficiency is comparatively low and the products are poorly designed, leading to great energy-saving potential. For example, electricity consumption of air conditioners accounts for about 20% of China's total electricity consumption and 40% of the summer electricity peak load in large and medium cities. However, less than 5% of units sold in the domestic market in 2009 reached the standard's highly efficient level of grade 2 above. The electricity consumption of electric motors and their related drive systems accounts for about 60% of China's total electricity consumption; however, less than 2% of the domestic market share consists of energy-efficient electric motor products. Promoting the energy efficiency and market shares of main energy-consuming products has become an important determinant of achieving energy conservation and emission reduction targets throughout the world.

I.1.2 The Need for Implementing the China Energy Efficiency Label System (CEELS)

In order to improve the energy efficiency of main energy consuming products, the government should develop and implement more stringent energy efficiency standards. Simultaneously, the government should improve the mechanisms by which standards are implemented to emphasize work to expanding these efficiency standards, fully emphasizing minimum efficiency standards, energy-saving standards and energy efficiency ratings.

Energy efficiency label systems have been widely regarded as a means to improve energy-saving and management with a relatively minor investment, resulting in quick effects, a great impact on consumers and significant energy-saving and environmental protection benefits; such labeling programs have achieved outstanding economic and social benefits and are accepted by many countries. Currently, energy labeling has been effectively implemented in over 40 countries and regions, covering 80% of the world's population, resulting in about US$800 million in energy saving output value every year. Moreover, the energy efficiency label system is believed to be one of the most effective policies in solving global climate change, and the cost is much lower than that of using new energy sources.

The implementation of the energy efficiency labeling system in China is an important part of the government's energy-saving, market-oriented management efforts; an effective way to promote enterprises' energy-saving technologies and the continuous improvement of product energy efficiency through market mechanisms; an urgent necessity for the standardization of product markets and the creation of fair markets; and a key in improving the quality and market competitiveness of China's products and actively deal-ing with green trade barriers. The implementation of the energy efficiency label system in China has great significance in improving the energy efficiency of energy-consuming equipment, improving buyers' awareness of the need for energy saving, accelerating the building of an energy-saving society and addressing the energy constraint contradictions encountered in building a well-off society.

I.1.3 Developments in CEELS Implementation

The "Administration Regulation on Energy Efficiency Labels," promulgated on the 1st of March 2005 marked the formal establishment of CEELS in China. The implementation of CEELS is based on "enterprise self-declaring plus information recording plus market supervision." Enterprise self-declaration is the key feature of CEELS, and calls for the enterprise to arrange product energy efficiency testing, determine the label information by itself according to the testing results and relevant standards, apply the label by itself, and being responsible for the accuracy of the label information. The "recording of EEL information" is the main management measure, and includes the verification and publication of EEL information. The "market supervision" measure is a means to ensure the effective implementation of CEELS.

Currently, the CEELS covers 19 products in 4 major fields. These product fields are household appliances, industrial equipment, lighting equipment and office equipment and include products such as room air-conditioners, household refrigerators, electric washing machines, individual air-conditioners, self-ballasted fluorescent lamps, high pressure sodium lamps, gas water heaters, water chiller units, small and medium-sized three-phase asynchronous motors, variable speed room air-conditioners, multi-connected air-conditioner (heat pump) units, household induction stoves, electric water heaters, computer monitors, photocopiers, air compressors, AC contactors, automatic rice cookers, and AC electric fans. Based on the active efforts and cooperation of all parties, the implementation of CEELS has saved in total 90 billion kWh electricity, leading to significant economic and social benefits. The government has put more and more emphasis on CEELS. The implementation effectiveness of CEELS is mainly due to the following four aspects.

First, the pace of implementation has rapidly increased. Energy efficiency labeling has been carried out for 19 types of products in 5 batches successively in China ever since the first products catalogue was issued in November 2004. So far, the number of enterprises with products recorded by China Energy Label Center (CELC) exceeds 1,600; the number of product models recorded by CELC exceeds 80,000; and over 300 laboratories are also recorded by CELC. The China National Institute of Standardization (CNIS) has started to research and prepare the sixth products catalogue, and plans to increase the number of product types covered by CEELS to more than 20.

Secondly, CEELS's energy savings achievements are remarkable. After implementing the energy efficiency labeling system for over four years, more than 90 billion kilowatt hours of electricity has been saved, which can be converted to more than 30.00 million tons standard coal. Thus CEELS goes far towards the realization of the energy saving and consumption reduction targets measured by energy consumption per unit GDP in the "The 11th Five-Year Plan."

Thirdly, the energy efficiency of energy consuming products has effectively improved and the markets for such products are increasingly transforming into high-efficiency product markets. According to statistics, compared to the year 2005 (before the implementation of CEELS), the average energy efficiency level of air conditioners has increased by 6.4%, and the market share of high efficiency air conditioners increased from less than 1% to 5%. The average energy efficiency of household refrigerators has been increased by 4.98%, and the market share of energy-efficient refrigerators accounts for more than 80% at present.

Fourthly, a legal foundation has been established. In the newly revised "Energy Conservation Law of People's Republic of China" and the "Circular Economy Promotion Law of the People's Republic of China", the provisions relating to energy efficiency labeling have been added, and the management mechanism and penalty methods have been clearly defined, thus establishing the legal foundation for incorporating the energy efficiency labeling system as an important national energy saving management measure.

I.1.4 The Need for Strengthening Energy Efficiency Testing Laboratories' Management and Facilities

"Enterprise self-declaration" is the key feature of CEELS and includes the enterprise's self-testing of energy efficiency indicators, determining the label information by itself according to the test results and relevant standards, applying the label, being responsible for the accuracy of the label, and simultaneously accepting supervision and inspection.

In recent years, through several random market inspections and investigations of national and local supervision departments, some enterprises and third-party laboratories were found to not have sufficient energy efficiency testing capacity and to be making false reports about the testing equipment and their capability to CELC, thus exerting a bad influence on the validity and veracity of the energy efficiency label system and disturbing the fair market environment. Since the implementation of CEELS, gravely fraudulent label information has also been discovered. In addition, through yearly investigations and research on testing enterprises, it has been found that each enterprise apparently has greatly different testing scopes and laboratory capabilities. For some products, there are a large number of small-scale manufacturers, and energy efficiency testing laboratories for such products have failed to meet the levels of management, equipment and personnel needed for testing. Thus the reliability of data for such products is low. For example, in the self-ballasted fluorescent lamp industry, due to the low technological requirements for assembly and production, there are at least thousands of manufacturing enterprises across the country. However, the number of large scale enterprises in this products market recorded by CELC is less than 20. The accuracy problems in such testing facilities are serious. It follows that the urgent task at present is to improve the testing capabilities of related enterprises and third-party laboratories through regulating their management, improving the testing facilities, and enhancing the operation skills and number of personnel.

I.1.5 Domestic and International Developments in Round Robin Testing

Round robin testing is an important type of test activity. In round robin testing, two or more laboratories test the same or similar samples according to pre-determined conditions. The testing process and results are also evaluated in order to check the operational conditions of laboratory devices, thus ascertaining the testing capacities of the laboratories in question, ensuring the accuracy of testing data and continued reliability of testing results, improving the quality and testing skills of related personnel, and identifying existing problems and disparities in the methods or circumstances of other laboratories. Being able to translate this information into data statistics, generalizations, and analysis for a reasonable evaluation of testing results is the key to successful round robin testing. If a laboratory's testing results are satisfactory, it indicates that the integrated indicators of testing technologies and equipment meet related requirements, and the laboratory conditions should be maintained and consolidated. If a laboratory's testing results consistently have outliers, the laboratory should take effective corrective and preventive measures to avoid future testing errors.

Compared with other quality control methodologies, round robin testing is scientific, simple, practical, and is the internationally accepted model of capacity verification. It has been adopted by many developed countries, and there are many case studies and best practice lessons to inform the refinement of laboratory capacity. In domestic and international laboratory accreditation activities, a laboratory's testing capabilities are evaluated by conducting round robin tests. International policy documents related to this effort include ISO/IEC Guide 43:1997 "Proficiency Testing by Inter-laboratory Comparisons ", "Requirements for Proficiency Testing Organizers" developed by the International Laboratory Accreditation Cooperation (ILAC), the APLACPT001 "Calibration Laboratories Comparison," the APLACPT002 "Testing Laboratories Comparison and "Requirements for Mutual Recognition" developed by the Asia Pacific Laboratory Accreditation Cooperation (APLAC). In China, the China National Accreditation Committee for Laboratories (CNACL) revised National Standard GB/T 15483-1995 for comparative testing, and clearly stated in the national laboratory accreditation guideline that laboratories should regularly carry out round robin testing. In domestic and international large-scale monitoring projects, quality control procedures are analyzed using round robin testing after confirming that all the participant laboratories have met related requirements for round robin testing, including personnel skills, reference values, internal quality control requirements, and sample assessments inspections to ensure that the results can be reasonably evaluated. In China, round robin testing is widely used by enterprises, non-profit organizations, professional quality inspection agencies, calibration agencies, and third-party laboratories, and plays an important role in various fields such as standard solution preparation in chemical analysis, tobacco quality testing, air volume and pressure measurements, safety testing of electronic products, vehicle emissions testing, fiber testing, road experiments, etc.. Through the government's effort to use technical standards to vigorously promote energy-efficient products, energy efficiency labels, financial subsidies and other measures, the round robin testing of main energy-consuming products is gradually increasing.

I.2 Necessity and Feasibility of Conducting Energy Efficiency Round Robin Testing for Air Conditioners

The necessity and feasibility of conducting consistent comparisons of the energy efficiency testing data for room air conditioner shall be analyzed in the context of the air conditioning industry, the profile of the market, the products' energy consumption status, their energy-saving contribution, testing technology levels, test conditions and capacities, international energy efficiency standard and labeling schemes for such products, the attitudes of relative parties, the accumulation of practical experiences during previous comparison, etc.

As for the necessity of testing, room air conditioners are a mature technology in a mature industry and market, with a wide range of usage, fast growing production, large energy consumption and great energy-saving contribution; however, testing technology is not unified, and differences are apparent in laboratory testing facility conditions and capabilities. Furthermore, international air conditioner energy efficiency standards and labeling efforts lack coordination and mutual recognition. These factors all highlight the urgency and importance of conducting consistent comparisons of energy efficiency testing data from room air conditioners, and thus improving laboratory testing capabilities and ensuring the accuracy of energy efficiency labeling information.

Conducting round-robin testing of room air conditioners' energy efficiency data is a means towards the self-development and improvement of the air conditioning industry and the transformation of our markets towards energy-efficient products; an effective way to improve the energy efficiency testing capabilities of laboratories in China; a necessary guarantee for the effective implementation of CEELS; and an essential impetus for the coordination and mutual recognition of international standards and labeling. As for the feasibility, the reasonableness and operability of conducting such a consistency check in the air conditioning products category is indicated by the mature nature of the industry, the high degree of brand concentration, the extensive support from relative parties and the accumulation of previous practical experience on consistent comparison of energy efficiency testing data of room air conditioners in China.

I.2.1 Necessity for Air Conditioner Round Robin Testing

I.2.1.1 Air Conditioning Industry and Market Profile

I.2.1.1.1 Air Conditioning Industry Profile

China’s air conditioning industry started in the 1950s and developed through the acquisition of techniques from the former Soviet Union. Prior to China’s reform and opening up, the industry was at a low level of development. After the 1980s, with economic reforms and growing international trade, China’s air conditioner market began to expand rapidly. The high profits and huge market potential of the early years of industry development and expansion attracted a lot of private capital, which led to an evident sellers’ market. This further created a larger number of domestic air conditioning product manufacturers with large scale and capability, and thus started the rise of China’s air conditioning industry.

Since the 1990s, a large group of foreign companies began to enter China, which promoted the intense competition in Chinese markets, and furthered the progress and improvement of the whole industry in all aspects. It is in this particular situation that China became the second largest room air conditioner consumer market and the largest producer of air conditioners around the world only after just over 10 years of development. According to statistics, over the past 10 years, China’s air conditioning industry had maintained an average growth rate of 30% per annum. By 2005, the annual output of the whole industry was nearly RMB 230 billion with exports of more than USD 5 billion. According to relevant data, after the long period of rapid growth, many enterprises have started to face a new round of operations restructuring and product design adjustment in recent years. Therefore the industry annual growth rate is expected to drop slightly compared to the previous peak period, but will remain at about 15%.

China is stepping into the home territories of air conditioner manufacturing giants. At present, China exports air conditioners to more than 200 countries and regions around the world. In 2007, China exported USD 100 million worth of air conditioner products to 14 major countries and regions, such as United States, Japan, Hong Kong, Italy, Spain, etc., and newly adding four more countries (including Russia, India, and Venezuela) to the USD 100+ million list. The American market accounts for one-fifth of China’s room air conditioner exports, followed by Japan and Hong Kong, and the corresponding export amounts are USD 1,259 million, USD 523 million and USD 395 million, respectively, in total accounting for 34.28% of China’s air conditioner exports. In the short term, Chinese enterprises can take advantage of low labor costs and large-scale production to provide high cost-effective air conditioning products for the international market, but these advantages are gradually being shared and diluted by other air conditioner manufacturers, brand manufacturers and distributors throughout the world. In the long term, Chinese air conditioner enterprises need to build their own core strengths and seek development through technology improvement and innovation, scale development and specialization. Besides, with the history and features of China’s air conditioner manufacturing industry and China’s abundant labor resources, the status of China as room air conditioner manufacturer and export base will be impacted by further consolidation and enhanced throughout a long period in the future.

Currently, the rising price of raw material inputs for air conditioner and the decline of product market prices are presenting challenges to the domestic air conditioners market. Meanwhile, the imbalance between supply and demand makes brand reshuffling inevitable. Brands within the domestic air conditioner market will become further concentrated and competitive advantages will be attained through technology innovation and brand recognition, and market share will further concentrate in a few superior enterprises. Moreover, industry profits have been falling. Data from the National Bureau of Statistics shows that the average profit margin for air conditioners has dropped by nearly 50% in four years. Energy-saving will be the trend into the future, while high-energy-consuming air conditioners will be eliminated.

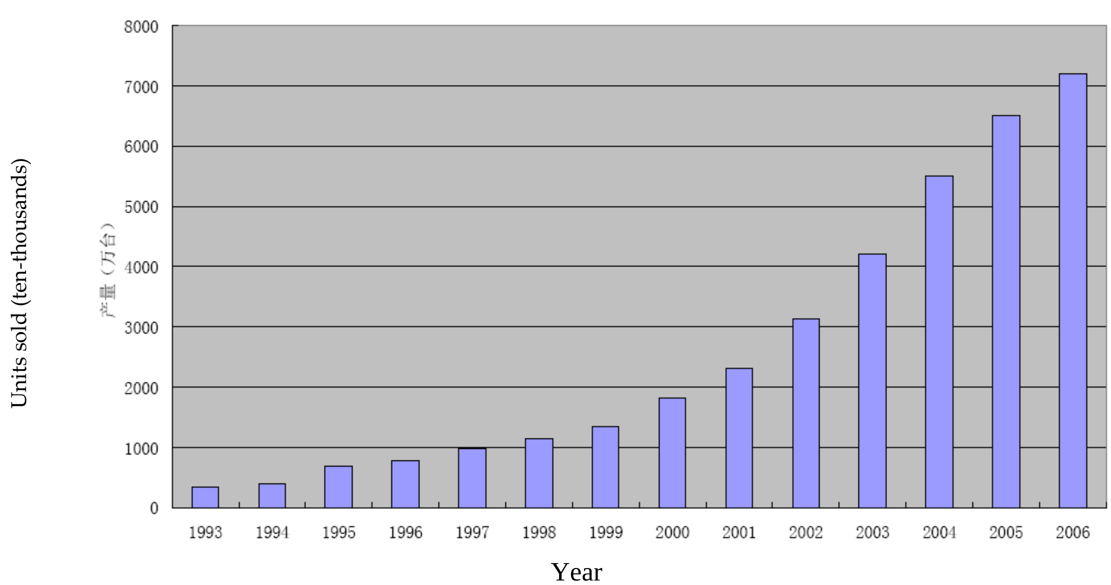
I.2.1.1.2 Air Conditioner Market Profile

Room Air Conditioner

China's room air conditioning industry is one of the fastest developing industries in the post-reform and opening up period, and its growth has dramatically affected the country and people's livelihood. Over the past 20 years, product quantity, number of enterprises, production and sales and market holdings have all grown rapidly, bringing numerous and unexpected changes. Air conditioners have transformed from the exclusively luxury status of the past to an everyday product while product price, variety, quality and the like have all seen significant changes and market competition is extremely fierce.

The following figure shows the changes in production and export volumes of room air conditioners of China over the years.

Figure 1 Production Volume of Room Air Conditioners in China



The main users of room air conditioners are residential households. According to market data gathered in June 2009, Grades 3 to 5 low energy efficiency products are still the dominant products in China's fixed-frequency room air conditioners market, accounting more than 85% of total market share, while the market share of Grades 1 and 2 high energy efficiency products was only about 6%. The market share of inverter room air conditioners has always been small at about 8%. "Low energy efficiency and inflated prices" could be used to describe the current air conditioner market context. First, when it comes to implementing energy-saving design measures, China's air conditioner manufacturers have always lacked internal impetus and external pressure. In addition, due to the price war caused by long-term and disordered fierce competition, the energy efficiency of air conditioning products is actually declining year-on-year. There are significant gaps between the energy efficiency of air conditioning products produced domestically and those produced in advanced developed countries. This disparity is especially noticeable in the products of some small and medium sized Chinese enterprises and in "specially-priced products". Those inefficient products consume a lot of energy and lead to the generally low average energy efficiency level of China's current air conditioner market.

Since the implementation of the "Energy-Efficient Products Subsidy Project" policy on June 1, 2009, the air conditioner market has been indicating an obvious trend of transformation to an energy-efficient products market. Almost all the major air conditioner enterprises have stopped producing Grades 4 and 5 products and a low number of Grade 3 products are produced mostly to support the national "Household Appliances to the Countryside" program. Major vendors like Gome, Suning, etc. have completely stop selling low energy-efficiency products. At present, the market share of Grades 1 and 2 fixed-frequency energy-efficient room air conditioners is more than 40%, and is expected to reach 50% or even nearly 70% next year. So far, 27 enterprises and 4,317 models of energy-efficient room air conditioners have been included in the financial subsidies promotion directory. Under the subsidies program, in the second half of 2009, 5 million units sold were as energy-efficient air conditioners, which is five times the total number sold the previous year. The price of energy-efficient air conditioners with a cooling capacity (CC) of 3,486 W decreased by more than RMB 1,000 on average, and the price of these units is now at the same level as that of the inefficient air conditioners with the same CC specifications. State financial subsidies are both accelerating the elimination of inefficient air conditioners in China and increasing the overall energy efficiency level of air conditioners by 15%. Extrapolating from the 5 million energy-efficient air conditioners promoted and used last year, it is estimated that China can save 15 terawatt hours of power every year and reduce the emission of 1.4 million tonnes carbon dioxide and 6000 tonnes sulfur dioxide.

In addition, another kind of room air conditioner product is the inverter air conditioner, which adopts some other technologies such as AC inversion and DC speed adjustment to quickly change the compressor speed, to achieve energy-efficient adjustable cooling capacity. The core technology inputs of the inverter air conditioner, such as the compressor and inverters, depend on imports. The market share of inverter air conditioner is small with a total output of about 200 million units. The sale price is about RMB 1,000 higher than that of the ordinary air conditioner, which is the main cause of this technology's low market share. However, we note that although the "Energy-Efficient Products Subsidy Project" policy currently only offers financial subsidies for fixed-frequency air conditioners, the market share of inverter air conditioner has not dropped. On the contrary, this technology's market share shows an increasing trend when sellers lower their sale prices, reaching about 15% now, among which the market share of Grade 1 and 2 energy-efficient inverter air conditioner is about 4%, accounting for about 25% of sold inverter air conditioner units. Of course, this is mainly because the inverter air conditioner represents the development direction of air conditioner energy-saving technology, and enterprises are aware that inverter air conditioners will dominate the air conditioner market in the future.

Unit-Type Air Conditioner

The main users of the unit-type air conditioner are commercial customers. At present, the unit-type air conditioner market in China is dominated by energy efficiency Grades 4 and 5 units, but the share of products above Grade 2 is gradually increasing due to the continuous building energy use enhancements. However, rising production costs will result in rising sales prices.

VRF Air Conditioner

The main users of VRF air conditioners are commercial users and large-scale households, and VRF air conditioners usually require professional handling.

I.2.1.1.3 Necessity Analysis

On one hand, product technology and quality are both greatly increasing as the air conditioning industry rapidly develops, the standard system is gradually perfected, the testing methods are gradually popularized, international trade increases and certification and labeling activities are widely upheld. Demand for the further development of the air conditioning manufacturing industry determines the necessity of enhancing general product testing capabilities, and an important means of improving testing capabilities is to improve the consistency of energy efficiency testing data comparison activities.

On the other hand, with respect of the air conditioner market, under the national financial subsidy policy, the market trend is increasingly towards energy efficiency. Energy efficient products have become prominent in the market, and energy efficiency performance is the index by which such products are being judged. The production and sales of such products depend on the effectiveness of market supervision, and thus the market is directly determined by the skill level of energy efficiency testing at laboratories. Therefore, using consistent comparison activities to vigorously check the accuracy of energy efficiency testing data will guarantee the accuracy and authority of the energy efficiency labeling information, ensure the effective implementation of the national financial subsidy policy, and help speed the market transformation to energy-efficient air conditioning products. In short, this comparison project is validated by the contexts of both the air conditioner industry and the market for these products.

I.2.1.2 Energy Consumption and Energy Saving Potential of Air Conditioners

I.2.1.2.1 Analysis of Energy Consumption and Energy-Saving Potential

Energy consumption in China has increased 5% per year since 1985, and electricity consumption has increased even faster, along with accelerated industrialization and urbanization in this period. With increasing standards of living and economic production and the resultant increase in air conditioner usage, energy savings air conditioners have become a main target of government energy-saving and enterprises technology development activities.

The air conditioner market in China developed rapidly and has become the third largest air conditioner market following the United States and Japan, accounting for 12% of the world air conditioner market share. At present time, the annual sales volume of air conditioners is increasing year-on-year, with annual power consumption of air conditioners up to 100 billion kWh. At the same time, air conditioner use accounts for about 40% of peak electricity load, which aggravates the peak-valley difference and reduces the grid load factor, resulting in the policy of "switching off power grids to limit power usage" in 2/3 provinces in China in 2003.

Industry professionals believe that the energy savings potential of air conditioners is large and there is much work to do. Air conditioner systems in buildings in China take up 40% to 60% of the total power consumption of the entire building. At least half of the total energy-saving potential in China (estimated at over RMB 30 billion every year) could be saved through air conditioner energy savings. Total air conditioner output in China surpassed 90 million units in 2008. It is estimated that when China realizes a fully "middle-class society" in 2020, the amount of energy saved by reducing the air conditioner peak load in China will be about 90 million kW. These savings are equal to the full load capacity of 5 Three Gorges power stations, and are 2 to 3 times the planned total installed nuclear capacity for 2020. Such energy savings would thus result in a RMB 400 billion savings in electric power station construction investments.

I.2.1.2.2 Necessity Analysis

The energy consumption and energy-saving potential of air conditioning products are large, so the promotion and application of energy-efficient products is of great significance to the cause of China's energy conservation and emission reduction. Running consistent comparisons of air conditioner testing data can effectively promote the improvement of the energy efficiency testing capacities of laboratories, the effective implementation of the energy efficiency labeling system, and the market transformation to energy-efficient products, and is of great significance to promote China's energy conservation and emission reduction efforts.

I.2.1.3 Status of Room Air Conditioner Energy Efficiency Testing Technology

I.2.1.3.1 Status of Energy Efficiency Testing Technology

The air enthalpy method and model room calorimeter method have been generally adopted in China's energy efficiency testing laboratories.

The air enthalpy method calculates the enthalpy difference of the incoming and outgoing air by measuring the dry and wet bulb temperatures of the incoming and outgoing air of the air conditioner, and then obtains the cooling capacity of the unit by multiplying the measured air flow by the enthalpy difference.

The model room calorimeter method is an important method for measuring the cooling capacity or heating capacity of the room air conditioner. Compared with the air enthalpy method, the special feature of the model room calorimeter method is that the working state of room air conditioner during testing and the working state in actual application are comparatively consistent. The principle of this method is a heat balance calculation, the basic concept of which is the total heat added to the insulated model room calorimeter is equal to the total cooling capacity. Whereas, the total heat taken away from the insulated model room calorimeter equals the total heating capacity.

If properly designed, the application scope of the balanced environment model room calorimeter can be expanded upon, and the model room calorimeter can meet the requirements of other performance tests and the related safety performance test for room air conditioners. In the past, because of notable technical difficulties in device design and the high cost of construction, most manufacturing plants and testing units of room air conditioners in China adopted a non-standard air-duct heat balance measuring device or a enthalpy difference measuring device to perform the test. Many laboratories also do not have the practical experience of conducting the energy efficiency test by the model room heat calorimeter method and cannot master the testing technology.

I.2.1.3.2 Necessity Analysis

Developing energy efficiency round robin testing for room air conditioner can promote communication and enhance testing technologies in all laboratories, and can greatly advance the development of air conditioner testing technology.

I.2.1.4 Air Conditioner Testing Facilities and Capabilities

I.2.1.4.1 Testing Facilities and Capabilities

The demand for industry development always promotes technological progress, while technological progress and the occurrence of new products always necessitate new technology testing requirements. Firms have a clearer understanding of the significance of strengthening self-owned test conditions, along with the establishment and improvement of testing standards, as well as the strengthening of market competition and international technology exchanges. Many enterprises have, since the end of the 1990s, spontaneously increase investments in product test methods. At present, many enterprises in the industry invest more than 10 million RMB in the facilities of their own product testing centers. The establishment of these test conditions not only helps the enterprise gradually improve their ability to conduct independent research, develop technological capabilities and increase core competitiveness, but also ensures that China's entire air conditioning industry will reach a higher level. Related fields are undergoing transformation due to the rapid development of computer and electronic technology and implementation in test device construction. Presently, various product test devices are fully automated in controlling operating conditions, adjusting various environmental parameters and data acquisition and analysis. The data can even be transmitted to other computers through networks to provide the user with valuable information gleaned through various analyses and comparisons. Therefore, the speed of new product development and the level of product performance can be greatly enhanced, effectively guaranteeing product quality and resulting in progress and prosperity for the industry.

The domestic household air conditioning industry has formed a batch of key production firms characterized by large production scales, strong product development and testing capabilities, high brand awareness and stable product quality. However, there are still some firms lacking product development ability and product performance testing capability. These enterprises neither have product performance testing capability nor do they entrust their products to third-party laboratory testing and therefore it is more likely that the performance indexes on the labels of such products are inaccurate.

Market research results and actual testing data show that even among the one or two hundred units of special air conditioner performance testing equipment presently used by domestic enterprises, there is still a large proportion which output poor test results with large data deviations in repeated tests. However, inconsistent testing data also comes from the testing equipment of large firms which was manufactured by well-known foreign companies. The reasons for such measurement deviations amongst testing equipment include: different systematic errors in the testing equipment itself, non-uniform enterprise-specific testing specifications, uneven skill levels of operators, etc. Regardless of the error type, the ultimate outcome is that test results are far from the actual value and the actual energy efficiency level of the tested air conditioner cannot be determined. The direct result of different measurements between firms and national quality inspection agencies is that the self-reported enterprise testing result and the self-labeled product energy efficiency parameters deviate from the actual product quality index, and therefore the energy efficiency label information is inconsistent with actual rating of the product.

I.2.1.4.2 Necessity Analysis

Despite significant improvements in the overall testing level and investment in testing facilities, the air conditioning testing facilities of energy efficiency testing laboratories reveal that there are still problems such as inadequate testing facilities in some laboratories, insufficient testing expertise in personnel, measurement deviation of testing equipment and the poor repeatability of testing data. These problems should be addressed by taking urgent measures to promote the upgrading and transformation of testing facilities through systematic round robin testing that will help reduce or eliminate measurement deviations and thereby ensure the accuracy and authority of the energy efficiency labeling information.

I.2.1.5 Domestic and International Energy Efficiency Standards and Labeling of Room Air Conditioners

Many countries have developed energy efficiency standards for room air conditioners, most of which are mandatory standards, with energy-efficiency labels implemented in some countries as well. A country's energy efficiency standards and labeling programs reflect national and regional methodology for determining energy efficiency indicators and the technical level of products. Different standards and labeling systems have been introduced and utilized in different countries and regions. The following paragraphs will focus on the energy efficiency standards and labeling programs for room air conditioners in the United States, European Union, Japan, Australia and other countries.

I.2.1.5.1 United States

The Appliance Labeling Rule (ALR), a mandatory system of energy efficiency labeling system in U.S., was established by the Federal Trade Commission (FTC) in 1980 and implementation followed with cooperation of the Department of Energy (DOE). The voluntary labeling program ("Energy Star") was established by the U.S. Environmental Protection Agency (USEPA) in 1992 with joint DOE efforts to promote the program beginning in 1996.

The FTC and DOE are responsible for implementation of the mandatory energy-efficiency labeling program ("Energy Guide"). In order to ensure the compliance of labeling information, the United States established a "compliance monitoring mechanism (CMS)" that requires manufacturers or suppliers to test a new product to determine its energy efficiency level prior to selling them and to submit a certification report to the DOE. The report includes energy efficiency data of the product and a complete compliance declaration. Once the DOE-approved minimum energy performance standards of a given product have been met, the EnergyGuide label can be used. By establishing an energy efficiency data information system and accepting complaints from consumers and manufacturers, the government can track and publicize the energy efficiency of products.

The final version of the Appliance Labeling Rule (ALR) revised by the U.S. Federal Trade Commission was approved and came into effect on February 29, 2008. The Rule requires manufacturers to use the yellow label titled "Energy Guide" and has clearly stipulated labeling method for the covered products. The specific requirements on label content for different products are also put forward. The requirements on the label states that the testing for products in compliance with DOE-issued standards shall be carried out and that the energy consumption or energy efficiency of covered products shall also be clearly indicated on the label. For some commercially available products, the label is also required to clearly indicate a given product's energy efficiency range (i.e., energy efficiency comparison range). The label is also required to clearly indicate the annual normal operating costs (which can be calculated by manufacturers based on recommendations provided by DOE).

The U.S. Energy Star label is a voluntary label which is awarded to efficient products with power consumption below the minimum standards. In most cases, the efficiency of the Energy Star product is higher than that stipulated by the minimum energy performance standards by 13% to 20%. In addition, the Energy Star label can also regulate the power consumption of electrical appliance under standby mode. In April 1993, President Bill Clinton signed a presidential order requiring all federal agencies to choose "Energy Star" labeled products in government procurement, which has contributed greatly to the label's success. The label has been applied to almost all of the energy-consuming products and has become one of the key criterions for consumers when purchasing energy-consuming products. It has also been introduced in Canada, Japan, the European Union, Australia and other countries and has become one of the internationally recognized labeling programs amongst participating countries.

The U.S. energy efficiency testing standard for room air conditioner is based on the ISO 5151 Standard, and the energy efficiency performance evaluation indicator uses the SEER (Seasonal Energy Efficiency Ratio) proposed by DOE. The definition of the indicator is completely different from that of the EER, and the currently required minimum SEER is 13 (calculations show that this is similar to Grade 2 of China Energy Efficiency Standards for Air Conditioner, under which the EER is 3.0).

I.2.1.5.2 European Union

The European Union enacted a unified energy efficiency labeling regulation (92/75/EEC) in September 1992, requiring manufacturers to label their products with energy efficiency rating, annual energy consumption and other information so that consumers and users can compare the energy performance of products amongst different brands. The energy label consists of an energy efficiency rating, main performance indicators, and model and product specifications. The energy label for air conditioners has been in effect since January 1, 2003.

Many EU countries formulated their own performance standards for room air conditioners in the 1970s, but the standards were unified with the establishment of the European Union. The basic equivalent of the performance standard for room air conditioner is the ISO5151 Standards for Test and Determination of Free Blast-Type Air Conditioners and Heat Pump. The corresponding energy efficiency testing standards is established on the basis of the ISO5151 Standard, with the energy efficiency performance evaluation indicator adopting the EER (Energy Efficiency Ratio). Currently, the highest rating of the energy label is A with an EER of 3.2 (equivalent to Grade 1 of China Energy Efficiency Standards on Room Air Conditioner with a EER of 3.2). The energy label is comprised of seven grades with the EER decreasing by 0.2 with each grade.

I.2.1.5.3 Japan

In 1998, the Japanese government made substantial amendments to the Energy Conservation Act, including the introduction of the "Top Runner Program" to curb the increase of energy consumption in civil and transportation sectors. It is different from the mandatory Minimum Energy Performance Standards (MEPS) adopted by most countries. The energy efficiency standard set by this program is the average performance standard amongst products of the same type rather than the MEPS. This implies that manufacturers can manufacture products below the standard, provided that the manufacturers also manufacture other products with higher energy efficiency to ensure that the average performance of similar products is above the mandatory standard. Currently, the Top Runner Program is implemented by the Energy Saving Center.

The JIS C9612 Room Air Conditioner is a standard integrating performance and safety, in which the performance testing requirements and test methods are developed by adopting the ISO 5151 Standard equivalent. The JRA 4046 Calculation Basis for Seasonal Electricity Consumption of Room Air Conditioner is the standard for energy efficiency testing and evaluation of air conditioners, which is applicable to the calculation of seasonal energy consumption of air-cooled air conditioners. The energy efficiency performance evaluation indicator uses the APF (Annual Performance Factor), with a current APF value of 4.0.

I.2.1.5.4 Australia

The energy efficiency labeling in Australia adopts the management system of "test report + product approval and registration + energy efficiency labeling + evaluation and necessary punitive measures", which is also manufacturer-based certification. In 1999, Australia implemented a nationally unified energy efficiency labeling system, with air conditioner included in the mandatory energy efficiency labeling program. Commercially available products and products on the energy efficiency control list in Australia are required to adopt the energy efficiency label, with some products also required to fulfill the increasingly strict MEPS requirements.

The performance standard for air conditioners of Australia is based on the AS/NZS 3823 series of standards. The standard AS/NZS 3823.1.1 stipulates the test method for room air conditioners, equivalent to ISO 5151, with an additional supplement in AS/NZS 3823.2 that specifies the energy efficiency labeling requirements for the air conditioners under 65kW, and the MEPS value (i.e., EER) of the products.

I.2.1.5.5 Hong Kong, China

To help consumers select more energy-efficient products, the Electrical and Mechanical Services Department (EMSD) carried out the voluntary Energy Efficiency Labeling Scheme (EELS) for household appliances, office equipment and automobiles. The scheme aims to help consumers make the right purchase decision by providing them with information on energy consumption and efficiency levels of different products. In 2008, the Hong Kong government further passed the Energy Efficiency (Labeling of Products) Bill to promote a mandatory EELS.

Under the mandatory EELS, energy-using products provided in Hong Kong must be marked with an energy efficiency label informing consumers of the energy efficiency level of related products. The first group of energy-using products consists of air conditioners, refrigeration equipment and compact fluorescent lamps and was implemented in the first phase of the scheme implementation on May 9, 2008.

The Hong Kong performance standard for air conditioners directly adopts the ISO 5151 standard and uses EER as the energy efficiency performance evaluation indicator. Currently, the energy labeling is comprised of five grades, with the highest being Grade 1 with EER value of 3.04 (for split type), followed by EER of 2.72 for Grade 2 and 2.46 for Grade 3.

I.2.1.5.6 China

The measurement indicators in "GB12021.3-2004 Energy Efficiency Limit Value and Rating for Room Air Conditioner", the current energy efficiency standard of room air conditioners, are only for the cooling performance of air conditioners using EER. The energy efficiency rating of air conditioners is shown in Table 1:

Table 1 Energy Efficiency Ratings in Current Room Air Conditioner Energy Efficiency Standard

Type	Rated Cooling Capacity (CC) W	Energy Efficiency Level				
		5	4	3	2	1
Integrated type		2.30	2.50	2.70	2.9	3.1
Split type	CC≤4500	2.60	2.80	3.00	3.2	3.4
	4500<CC≤7100	2.50	2.70	2.90	3.1	3.3
	7100<CC≤14000	2.40	2.60	2.80	3.0	3.2

Analysis of energy efficiency standard statistics shows that most foreign energy efficiency standards are proactive, meaning that the implementation is usually 3 to 5 years after the release so as to provide manufacturers with enough lead time to adapt. The 2009 revision of China's Energy Efficiency Standard of Room Air Conditioner is also proactive. In the new version, the energy efficiency limit value is equal to Grade 2 of the original version. The details are shown in Table 2.

Table 2 Air Conditioner Energy Efficiency Limit Values Implemented in 2009

Type	Rated Cooling Capacity (CC) W	Energy Efficiency Ratio (EER) W/W
Integrated Type		2.90
Split Type	CC≤4500	3.20
	4500<CC≤7100	3.10
	7100<CC≤14000	3.00

Since the energy efficiency labeling system is introduced in detail in section I.1, it is not described again here.

I.2.1.5.7 Analysis of Policy Need

On one hand, air conditioner is often one of the first products to be covered by an energy efficiency labeling system in many countries, including China. Effective implementation of the energy efficiency label for air conditioners will promote the development and improvement of the energy efficiency labeling system throughout China. Achievement of this goal depends on effective testing of air conditioner energy efficiency and it is therefore necessary to carry out round robin testing and evaluation of energy efficiency testing data for room air conditioners.

On the other hand, because the room air conditioner energy efficiency standards of above mentioned countries and regions are all set in accordance with the technical requirements, test conditions and test methods specified in the international standard ISO 5151, the comparability of product performance is high. However, as a result of different local and national conditions amongst countries and regions, differences of performance indicators and other aspects of the standards exists. Consequently, the information on the energy efficiency label varies. In order to eliminate trade barriers as international trade in the air conditioning industry expands rapidly, coordination and mutual recognition of international standards and labeling has become a common trend. The improvement and emphasis on testing capability of China's energy efficiency testing laboratories will provide technical support and ensure successful coordination and mutual recognition of international standards and labeling.

I.2.2 Project Feasibility

All parties related to round robin testing of room air conditioner have generally expressed their support for the activity and previous practical experiences in this area serves as a useful reference, which increases the feasibility of the project.

I.2.2.1 Attitudes of Stakeholders

In market terms, the air conditioning industry and market are mature and market shares are increasingly concentrated amongst major brands with 80% market shares in the hands of 20% of the enterprises. Major manufacturers have better organization and management in this competitive industry. With technological advancements becoming a competitive market advantage, manufacturers have gained a deeper appreciation for the importance of technology development and testing facility upgrades. At the same time, they actively increase financial and human resources, equip their laboratories with energy efficiency testing facilities, gain considerable energy efficiency testing capabilities, develop greater understanding of the role and significance of round robin testing of energy efficiency measures, and thus have an overall supportive attitude towards carrying out the project.

For independent testing agencies and the third-party laboratories, energy efficiency testing has gained importance as the energy efficiency testing level became an important performance indicator for testing institutes under the State's active promotion of energy conservation and emission reduction. Therefore, it is quite necessary to actively organize and participate in such proficiency testing activities like round robin testing and enhance their energy efficiency testing level. Those laboratories are thus quite supportive to the round robin testing activity.

Industry management departments are generally supportive of the round-robin testing efforts as it regulates the development of the industry, including guiding progress in the testing technology levels of the industry and its role in accepting the social responsibility for building an energy-saving society.

For energy efficiency labeling authorities and implementing agencies, their implementation focus in energy efficiency labeling lays primarily in after-market evaluations. Therefore, it is important to promote the overall level of energy efficiency testing of major energy-using products in order to ensure the accuracy of the label information and the overall authority and credibility of the energy efficiency labeling system. As a result, the energy efficiency label authorities and implementing agencies provide full support to the round-robin testing activity.

I.2.2.2 Accumulation of Early Practical Experience

China has precedents in round robin testing of air conditioner products, including in 2006 when the China Consumers Association organized the comparative testing for the credibility of energy efficiency labeling information of air conditioners. Products used for testing covered 12 models of split-type room air conditioners produced by 12 manufacturers. The accumulation of such early practical experience provides a good reference point for carrying out the round robin testing of room air conditioners' energy efficiency levels.

I.3 Project Significance

The implementation of CEELS has led to significant improvement in energy efficiency of main energy-consuming products with important economic and social benefits. According to the "Energy Conservation Law" and the "Administration Regulation on Energy Efficiency Labeling", the products covered by CEELS, made and/or sold in China are required to carry out energy efficiency performance testing. In this case, the accuracy and reliability of the testing results can directly influence the creditability of the information on the label and the authority and gravity of the energy efficiency label. At present, the technical level of the laboratories conducting energy efficiency testing in China is remarkably lower than some developed countries, and the testing capacity and the accuracy of the testing results are in need of improvement. Room air conditioner is the earliest product for which the CEEL was implemented and has appropriate characteristics such as mature industry, market, and technologies; wide range of use with fast-growing production; energy-intensive use and high energy savings potential; not unified testing technologies with variations in testing equipment, conditions, and capabilities of laboratories; and does not have an mutually recognized energy efficiency standard and label. The effective implementation of room air conditioner energy efficiency label will have a tremendous impact on leading the development and improvement of the entire CEELS. By conducting round robin energy efficiency testing amongst foreign, national, local and manufacturers' laboratories in China, this project aims to analyze and evaluate the present situation of Chinese laboratories' energy efficiency testing using statistical analysis of testing results. Effort to identify and address existing problems impacting the further development of Chinese labs can then be undertaken. The general goals of this project is ensure the accuracy, reliability, consistency of the energy label information, strengthen the social credibility and capacity of international mutual recognition, and ensure the effectiveness of implementing the China Energy Efficiency Label System.

I.4 Developing the Implementation Scheme for Round Robin Testing

I.4.1 Development Process for the Implementation Scheme

I.4.1.1 Basic Information Collection and Preliminary Visits to Identify Target Products for Testing and Testing Facilities

- Collect information through various channels including networks, telephone, E-mail, etc.
- On May 18th, 2009, experts from the EEL Center of CNIS visited Laboratory 4. Its history, testing capabilities, and current development status were reviewed, and feedback on the proposed project implementation scheme was received during discussions.

- The split-type and fixed-speed room air conditioner is determined as the target product. Testing institutes are chosen and divided as 1 dominant lab and 5 reference labs. The testing methods are the air-enthalpy method and calorimeter method. The specific details are as follows:

  Calorimeter Method:
  Laboratories 1, 2, 4, 5, 6

  Air-enthalpy Method:
  Laboratories 1, 2, 3, 5

I.4.1.2 Analysis, Research and Drafting of the Implementation Scheme

The scheme was formulated following the relevant national regulations.

I.4.1.3 Experts Discussion

The project kick-off meeting was held on the 14th of August 2009 in Rongcheng city in Shandong province. The draft round robin testing scheme was thoroughly discussed and suggestions recorded in order ensure a scientific, stringent, rational, and operable implementation scheme, improve guidance on the project efforts and to ensure the project's success.

I.4.1.4 Formulation of Final Implementation Scheme

The draft plan was further revised and finalized based on discussion with experts.

I.4.2 Content of Implementation Scheme

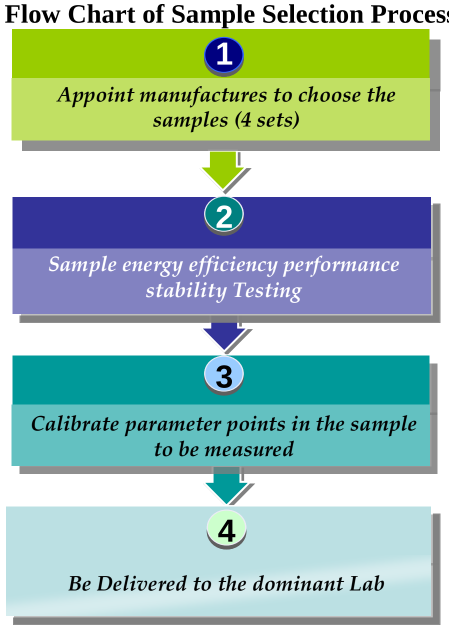
I.4.2.1 Sample Selection

Unlike the sample selection for general product quality testing, round robin testing of product's energy performance needs products that have steady and reliable performance to minimize the testing error caused by the product itself. In considering the importance of sample performance stability for round robin testing, the samples selected from the product line of manufacture were pre-screened. The specified scheme was as follows:

- According to the requirements of the round robin testing and the market sale situation of the room air-conditioners, China National Institute of Standardization (CNIS) appointed a manufacturer to select 4 sets of samples of the split and fixed-speed types;
- Sample customization time limit was set at two months;
- The manufacturer should calibrate parameter points to be measured in the samples, which should be confirmed by CNIS and dominant lab so that the dominant lab can determine the samples testing reference data;

- The manufacturer should propose protective measures to reduce damage to the samples during the packing, unpacking and transportation process;
- The manufacturer is in charge of filling in the "Sample Description Sheet", and delivering the samples to the dominant lab with the "Sample Transfer Record" filled out on both sides.

Figure 2 Flow Chart of Sample Selection Process



I.4.2.2 Energy Efficiency Testing

I.4.2.2.1 Testing Items

I.4.2.2.1.1 Cooling Performance

Number	Inspection item	Pursuant standards and provisions
1	Cooling capacity	GB/T17758-1999 GB/T 7725-2004
2	Cooling consumption power	GB/T17758-1999 GB/T 7725-2004
3	Energy efficiency ratio (EER)	GB 12021.3-2004

I.4.2.2.1.2 Heating Performance

Number	Inspection item	Pursuant standards and provisions
1	Heating capacity	GB/T17758-1999 GB/T 7725-2004
2	Heating consumption power	GB/T17758-1999 GB/T 7725-2004
3	Energy efficiency ratio(COP)	GB 12021.3-2004

I.4.2.2.2 Basis for Determination

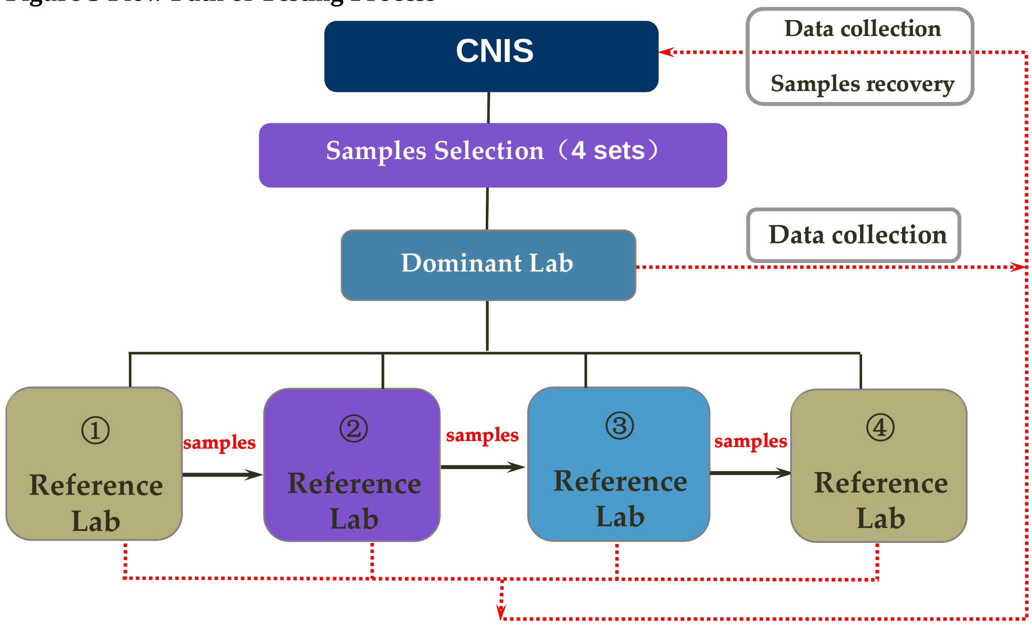
- GB/T 7725-2004 “Room Air-Conditioner”;
- GB 12021.3-2004 “The Minimum Allowable Values of the Energy Efficiency and Energy Efficiency Grade for Room Air-Conditioner”;
- CEL-002-2004 “Energy Efficiency Labeling Implementation Rules for Air-Conditioners”.

I.4.2.2.3 Testing Process

Due to special laboratory circumstances and to effectively reflect the testing capacity of Chinese labs, two different testing methods are selected: the enthalpy testing method and the calorimeter testing method. The number of labs selected for the enthalpy testing method and the calorimeter testing method is 4 and 5, respectively. The details of the testing process are as follows:

- The dominant lab is in charge of energy efficiency performance testing of all the samples to get the reference data including the installation conditions, environmental factors, equipments factors etc., and then fill out the “Round Robin Testing Process Record”, and present the “Round Robin Testing Report.”
- After completing the round robin testing, the dominant lab is responsible for delivering all the samples to other reference labs for testing in the circular path (See Figure 3);
- After completing the round robin testing, the dominant lab is responsible for delivering and sending the “Round Robin Testing Process Record”, “Round Robin Testing Report”, etc. to CNIS;
- All the reference labs should carry out energy efficiency testing for all conditions recorded in the “Round Robin Testing Process Record” presented by the dominant lab, fill in the “Sample Transfer Record”, and present its “Round Robin Testing Process Record” and “Round Robin Testing Report”;
- After completing the round robin testing, all the reference labs are responsible for delivering and sending samples and the following documents to CNIS within 5 days after testing completion: “Sample Description Sheet” (hard and electronic copies), “Sample Transfer Record”, “Round Robin Testing Process Record” and “Round Robin Testing Report”, certificate copies of verification officers involved in the round robin testing, etc.;
- CNIS is in charge of statistics and analysis of all reference data provided by the dominant lab and testing results provided by all reference labs, and then the final round robin testing report will be finalized.

Figure 3 Flow Path of Testing Process

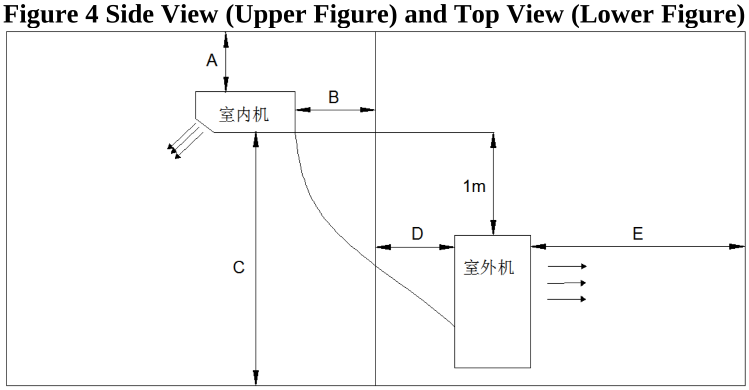


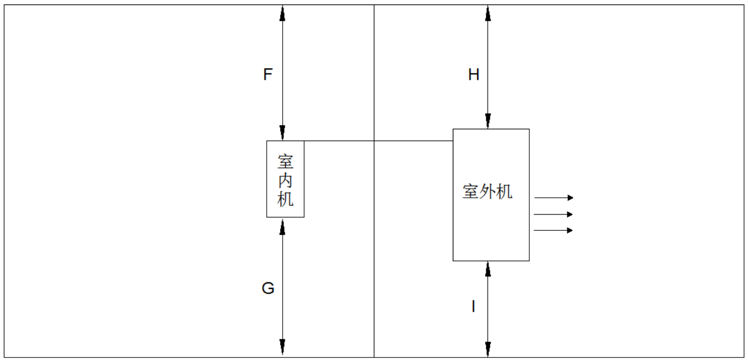
I.4.2.3 Other Considerations

I.4.2.3.1 Installation Requirements for Samples

- The installation of all the samples should be conducted following Figure 4 with the given power supply conditions: 220V±1%, 50Hz±1%. Half of the outdoor air-conditioner connection pipe should be placed outdoor, and the rest of the sample installation should follow regulations in GB/T7725-2004;

Figure 4 Side View (Upper Figure) and Top View (Lower Figure) of Sample Installation





- After the sample is installed, evacuation treatment should be adopted to evacuate air in the connection pipe and heat interchanger. Afterwards, the vacuum pressure should remain below 0.3kPa for 30min, and the pressure recovery should not exceed 0.05kPa;
- After vacuum treatment, charge 850g±5g R22 refrigerant for sample 1, 2, and 3, and 1700g±5g R410A refrigerant for sample 4;
- After the enthalpy difference method is applied for testing, the length of the connection air duct in the sample air outlet should not be longer than 0.5 m, and the shape of the air duct should not affect the sample air supply amount;
- The indoor part of the sample should be put horizontally and the condensed water should be removed smoothly;
- Preprocessing in any form is prohibited; the inner filter screen and the air outlet grille cannot be unpacked before testing.
- After completing the cooling performance testing, the samples do not need to be packed or unpacked again as the heating performance testing should be conducted immediately after.
- All reference labs should follow the specific installation conditions in the "Round Robin Testing Process Record" presented by the dominant lab to guarantee the comparability of the testing data.

I.4.2.3.2 Testing Environment Requirements

- After the samples have been ran with the power on, adjust the lab environment's working conditions to meet the standard's regulated requirements and then record testing environment data in the "Round Robin Testing Process Record";
- All reference labs should conduct energy efficiency testing under working environment conditions presented in the "Round Robin Testing Process Record" by the dominant lab;
- If the operating parameters of samples in the reference labs are not consistent with working environment conditions presented by the dominant lab, the labs should make other necessary adjustments such as confirming samples' cooling medium charging amount, cooling medium leakage, pipeline heat insulation, installation position and the labs' air sampling devices, air duct in the air outlet, and static pressure, etc.;

- All the reference labs should follow the specific testing environmental conditions in the "Round Robin Testing Process Record" presented by the dominant lab to guarantee the comparability of the testing data.

I.4.2.3.3 Stipulations on Transferring Samples

The transfer of samples should be jointly completed by CNIS and all designated testing labs, including checking the completeness of the package, inspection of samples' external appearance, and filling in the "Sample Transfer Record" etc. The transfer record should be copied for CNIS and both sides of the labs.

I.4.2.3.4 Stipulations on Transporting Samples

The dominant lab should deliver the samples to the reference labs on the day when the testing is completed. The samples should be personally carried and any other delivery way is prohibited.

I.4.2.3.5 Considerations for the Delivery and Testing Processes

- In case of sample failure during testing or the sample delivery process, the lab observing failure should not dispose of it independently but should report to CNIS immediately, and allow CNIS to deal with it according to the specific circumstances;
- The dominant lab and all the reference labs should strictly follow the testing plan and complete the task on time. In case of any delay due to unexpected circumstances, the lab should submit an immediate application to CNIS;
- When the verification equipment in labs breaks down or is damaged during testing, cause of the malfunction and the resolution should be recorded and then CNIS informed;
- CNIS may appoint related personnel to check the testing status of the labs at any time during the testing period to ensure the truthfulness and reliability of the round robin testing.

I.4.2.3.6 Round Robin Testing Report and Process Record Requirements

The "Round Robin Testing Process Record" should include the round robin testing summary, testing component uncertainty parameters, lab cooling (heating) capacity calculation formula, and description about testing deviation requirements. The "Round Robin Testing Report" should include testing results, data sheets, data curve of the entire testing process, and analysis of uncertainty of testing results.

I.4.2.3.7 Confidentiality Provisions

All the related personnel and members of experts group in the labs should keep testing results and reports confidential without exchanging data or disclosing any information about the testing results to the outside so as to guarantee fairness and objectivity of the round robin testing.

I.4.2.4 Main Participants and Respective Project Responsibilities

Responsible Unit: CNIS

Specified responsibilities are as follows:

- Identify testing items;
- Determine testing labs, including dominant lab and reference labs;
- Develop round robin testing implementation schemes and other documents;
- Address major disputes and controversies;
- Supervise the objectivity and fairness of the entire testing process;
- Collect and compile testing data, round robin testing process record, round robin testing report, etc.

Sample Provider

Specified responsibilities are as follows:

- Provide testing samples and calibrate samples' energy efficiency performance measurement parameters to facilitate the dominant lab in getting reference data for testing, and harmonize the state of the samples to be tested;
- Propose protective measures to prevent damage to samples during the sample packing, unpacking and transport process;
- Responsible for delivering the samples to the dominant lab.

Testing Labs

Dominant lab

Specified responsibilities are as follows:

- Provide accurate reference data, and provide round robin testing process record and round robin testing report;
- Examine and verify various conditions for testing, including installation conditions, testing environment conditions, etc. so that all the reference labs can implement uniformly;
- Responsible for delivering samples to reference lab;
- Abide by and execute confidentiality provisions.

Reference labs

Specified responsibilities are as follows:

- Complete energy efficiency testing following requirements in the round robin testing implementation scheme;
- Cooperate and collaborate with the dominant lab for testing according to the schedule;

- Provide testing results to CNIS on time;
- Abide by the confidentiality provisions.

Specified reference labs are:

- International level lab;
- National level lab;
- Local lab;
- Enterprise lab.

I.4.2.5 Main Participants

WANG Ruohong	Senior Engineer/Director, Male Division of Resource & Environment Standardization, CNIS
CHENG Jian-hong	Senior Engineer, Male Division of Resource & Environment Standardization, CNIS
Cao Ning	Engineer, Male Division of Resource & Environment Standardization, CNIS
Xia Yujuan	Engineer, Female Division of Resource & Environment Standardization, CNIS
Peng Yanyan	Engineer, Female Division of Resource & Environment Standardization, CNIS
ZHANG Xin	Engineer, Male Division of Resource & Environment Standardization, CNIS
WANG Geng	Engineer, Male Division of Resource & Environment Standardization, CNIS
BAO Wei	Engineer, Male Division of Resource & Environment Standardization, CNIS
WEI Bo	Engineer, Male Division of Resource & Environment Standardization, CNIS
WU Shangjie	Senior Engineer, Male China Household Electric Appliance Research Institute

DAI Shilong	Senior Engineer, Male Heifei General Machinery Research Institute

I.5 PROJECT ORGANIZATION AND EXECUTION

I.5.1 Sample Customization

1. Number: 4 sample sets, 3 of which are from leading domestic air conditioner manufacturers and 1 of which is an international round robin testing sample from Australia.

2. Product sample type: split type; fixed-speed;
Specific details of the 3 Chinese product samples are as follows:
Brand: Gree Electric Appliances, Inc. of Zhuhai
Model: KFR-35GW/K(35556)B1-N5
Cooling capacity: 3520 W
Heating capacity: 4000W
Input power: 1266 W (cooling)/1190 W (heating)
Voltage: 220 V
Frequency of power unit: 50 Hz
Energy efficiency ratio (COP): 2.78
Energy efficiency level: 5
Size of the interior/exterior units (cm): 845 x 275 x 180；848 x 540 x 320

Specified details of the sample from Australia are as follows:
Brand: Gree Electric Appliances, Inc. of Zhuhai
Model: GWHN18B5NK3NA (KFR-50)
Cooling capacity: 5300W
Heating capacity: 6060W
Input power: 1730 W (cooling)/1770 W (heating)
Energy efficiency ratio (COP): 3.06
Energy efficiency level: 3
Voltage: 230 V
Frequency of power unit: 50 Hz
Size of the interior/exterior units (cm): 1020 x 310 x 228；848 x 592 x 320

3. Production method: Manufactured by normal production line, with proven stability in energy efficiency performance.

I.5.2 Sample Delivery and Pre-Testing Preparation Work

The air conditioner manufacturer presented performance stability report, calibrated parameter points to be measured in the samples, which was confirmed by CNIS and the dominant lab. The manufacturer filled in the “Sample Description Sheet” and then delivered the samples to the dominant lab.

I.5.3 Project Kick-Off Meeting

On August 14th, 2009, the project kick-off meeting was held in Rongcheng city in Shandong province to officially launch project activities. International experience for round robin testing was introduced and the project implementation scheme was extensively discussed by the participating experts and feedback was collected. The representatives were from National Development and Reform Commission (NDRC), Energy Foundation (EF), Lawrence Berkeley National Laboratory (LNBL), CNIS, and all the sample laboratories.

I.5.4 Conducting the Energy Efficiency Round Robin Testing

The round robin testing timeline was as follows:

Duration	Responsible Institute
2009.10-2009.11.10	Laboratory 4
2009.11.11-2009.11.20	Laboratory 2
2009.11.22-2009.12.3	Laboratory 5
2009.12.6-2009.12.13	Laboratory 3
2009.12.16-2009.12.27	Laboratory 1
2009.12.31-2010.1.12	Laboratory 6

I.5.5 Participation of International Expert

An international expert, André Pierrot, participated in this RRT through visits to Laboratories 4, 2, and 1. CNIS helped make arrangements for the visit by communicating with test laboratories, setting visit schedules, and coordinating personnel to accompany the expert on his visit.

I.6 RRT RESULTS AND ANALYSIS

CNIS is in charge of the statistics, analysis and evaluation of the reference data given by the dominant laboratory and testing data given by participant laboratories.

I.6.1 Data Collection, Analysis and Result Evaluation Method

The consistency evaluation of energy efficiency indicators uses the robust statistical methods (Z ratio fraction)[1]. Robust statistical methods are not unduly affected by outliers or other small departures from model assumptions. In traditional statistical methods, the mean of a group data are susceptible to outliers, and the situation does not apply for robust statistical method, in which the mean is substituted by median, and standard deviation is substituted by Norm IQR (inter-quartile range).

[1] Note that this statistical method is primarily used for normalization exercises. More in-depth analysis of the testing data and results are presented in section II.

I.6.1.1 Data Collection and Statistical Analysis

The participating laboratories should test the specified parameters of each sample under defined conditions, and submit the testing results to CNIS.

After all the participant laboratories have finished testing, CNIS adopts robust statistical methods to analyze the test results data in the form of overall statistics. The related statistics are as follows:

Number of results: The number of effective results reported by participant laboratories following the implementation scheme of round robin testing.

Median: A median is described as the numeric value separating the higher half and the lower half of all the observations. The median of a finite list of numbers can be found by sorting all the observations from the lowest value to highest value and determining the middle one.

Inter-quartile range (IQR): The difference of upper quartile and lower quartile. A larger IQR value indicates greater dispersion of observations. Conversely, lower IQR value represents a smaller dispersion coefficient of observations. Upper quartile (Q3) refers to the value smaller than a quarter of all the observations. Lower quartile value (Q1) refers to the value larger than a quarter of all the observations.

Norm Inter-quartile range (NIQR): It is obtained by multiplying IQR with the coefficient 0.7413, and is equivalent to standard deviation.

Robust coefficient of variation (Robust CV): It is obtained by dividing NIQR with the median, and is equivalent to the classic coefficient of variation (i.e., the result of standard deviation divided by mean).

Outlier: Data that is considered to be significantly different from others through statistical analysis. In this round robin testing, the Z ratio fraction is calculated by robust statistical methods. When the absolute value of Z ratio fraction is larger than or equal to 3, the corresponding data is considered to be an outlier. The calculation formula for Z ratio fraction is as follows:

$$Z = \frac{x_i - M}{NIQR(x_i)}$$

Where, x_i is measured value, and M is median.

Maximum, minimum: The maximum and minimum values of a group of data.

Range: The difference between maximum and minimum values of a group of data.

I.6.1.2 Evaluation of Laboratory Test Results

The Z values of each laboratories can be calculated from the overall statistics (median and NIQR).

In this round robin testing, the following criteria are employed to evaluate the testing results.

$|Z| \leqslant 2$, satisfactory result;

$2 < |Z| < 3$, problematic result;

$|Z| \geqslant 3$, outlier (unsatisfactory result).

I.6.2 Evaluation and Analysis of Test Results

In this round robin testing, there were originally 4 customized samples. But sample 2 was damaged on its way to Laboratory 1, resulting in the final number of sample utilized being only 3. There were 6 parameters tested for each sample, including cooling capacity, cooling input power, EER, heat capacity, heating input power, and COP. The testing method used was the calorimeter method, the air enthalpy method or both methods. A total of 6 laboratories participated, which all tested the 6 parameters for each of the 3 samples and submitted testing results as shown in Table 3. For each item of each sample, there were a total of 6 results.

It should be noted that two kind of testing methods were used in this round robin testing. Except for Laboratory 3, the other 5 laboratories all have calorimeter testing capabilities. For the 5 other laboratories, the calorimeter test method is preferred in robust statistical analysis.

Table 3 Catalog of Reported Data by Participating Laboratories

Sample No.	1				2				3				4			
Testing method	calorimeter		enthalpy		calorimeter		enthalpy		calorimeter		enthalpy		calorimeter		enthalpy	
Mode	C	H	C	H	C	H	C	H	C	H	C	H	C	H	C	H
Lab 1	√		√	√					√		√	√	√		√	√
Lab 2	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Lab 3			√	√			√	√			√	√			√	√
Lab 4	√	√			√	√			√	√			√	√		
Lab 5	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
Lab 6	√	√							√	√			√	√		

Note: C refers to cooling, and H refers to Heating.

I.6.2.1 Statistical Results

All the testing data were analyzed using statistical methods, and the details are shown in Table 4 and Table 5.

Statistical analysis results of cooling capacity data: Among the 6 testing results, there are 0, 0, and 1 unsatisfactory result for sample 1, 3, and 4, respectively, corresponding to percentage proportions of 0%, 0%, and 16.67%.

Statistical analysis results of cooling input power data: Among the 6 testing results, there are 1, 1, and 1 unsatisfactory result for sample 1, 3, and 4, respectively, corresponding to percentage proportions of 16.67%, 16.67%, and 16.67%.

Statistical analysis results of EER data: Among the 6 testing results, there are 0, 1, and 0 unsatisfactory results for sample 1, 3, and 4, respectively, corresponding to percentage proportions of 0%, 16.67%, and 0%.

Statistical analysis results of heating capacity data: Among the 6 testing results, there are 0, 0, and 0 unsatisfactory results for sample 1, 3, and 4, respectively, corresponding to percentage proportions of 0%, 0%, and 0%.

Statistical analysis results of heating input power data: Among the 6 testing results, there are 0, 2, and 0 unsatisfactory results for sample 1, 3, and 4, respectively, corresponding to percentage proportions of 0%, 33.33%, and 0%.

Statistical analysis results of COP data: Among the 6 testing results, there are 0, 0, and 0 unsatisfactory results for sample 1, 3, and 4, respectively, corresponding to percentage proportions of 0%, 0%, and 0%.

I.6.2.2 Analysis and Discussion of Statistical Results

I.6.2.2.1 By Test Item

The 18 testing data points of 6 laboratories and 3 samples corresponding to each test item is treated as a whole, among which the percentages of satisfactory, problematic, and unsatisfactory results (outliers) are calculated as shown in Table 6.

The highest percentages of satisfactory results correspond to heating capacity and COP at 100%, followed by 89% for cooling capacity and EER. The percentages corresponding to cooling input power and heating input power is the lowest at 78%. Therefore, the laboratories should strengthen their capacities in input power testing.

I.6.2.2.2 By Laboratory

The 18 testing data points of 3 samples and 6 testing items corresponding to each laboratory is treated as a whole, among which the percentages of satisfactory, problematic, and unsatisfactory results (outliers) are calculated for each laboratory.

All the testing results of laboratory 1 are satisfactory. There are 2 unsatisfactory results for laboratory 2; 3 problematic results for laboratory 3; 1 problematic result and 1 unsatisfactory result for laboratory 4; 1 problematic result and 1 unsatisfactory result for laboratory 5, and 1 unsatisfactory results for laboratory 6. Based on this, the percentages of satisfactory, problematic, and unsatisfactory results (outliers) for each laboratory are calculated as shown in Table 7.

Laboratory 1 has the highest percentage of satisfactory results at 100%, while laboratory 3 has the lowest percentage at 83.33%. Laboratory 2 has the highest percentage of unsatisfactory results at 11.11%.

The above results show that most laboratories had problematic or unsatisfactory result, indicating that there were testing error among them, and the consistency of testing data need to be further improved. The errors may be due to differences in the operational status of equipment or skills of operators. It is noteworthy that the percentages of satisfactory results for laboratories 2 and 3 are the lowest. Thus they should strengthen the verification and improvement of laboratory quality control measures, equipment operation status, and operating skills and capabilities of personnel.

Table 4 Statistical Results for Test Data

Sample No.	Lab No.	Cooling capacity		Cooling input power		EER		Heating		Heating input power		COP	
		Z	Evaluation	Z	Evaluation	Z	Evaluation	Z	Evaluation	Z	Evaluation	Z	Evaluation
1#	1	0.38	S	-0.67	S	1.01	S	1.21	S	-0.14	S	1.03	S
	2	1.00	S	11.30	U	-1.46	S	-1.02	S	-0.41	S	-0.05	S
	3	1.94	S	1.01	S	2.59	P	-0.26	S	2.12	P	-0.83	S
	4	-0.05	S	-1.01	S	0.56	S	0.19	S	-0.80	S	0.83	S
	5	-0.55	S	-0.17	S	-0.34	S	0.60	S	1.29	S	0.05	S
	6	-0.69	S	0.17	S	-0.56	S	-1.75	S	0.14	S	-0.74	S
3#	1	0.86	S	-0.35	S	1.54	S	1.99	S	0.12	S	1.09	S
	2	0.45	S	3.83	U	-0.26	S	-0.74	S	0.61	S	-0.55	S
	3	2.45	P	-1.22	S	3.59	U	0.33	S	-0.10	S	0.23	S
	4	-0.38	S	0.35	S	0.00	S	0.62	S	-4.05	U	0.63	S
	5	-0.45	S	0.35	S	0.00	S	-0.54	S	5.52	U	-0.78	S
	6	-1.02	S	0.52	S	-0.51	S	-0.33	S	-0.12	S	-0.23	S
4#	1	-0.48	S	-0.42	S	-0.36	S	0.20	S	-1.73	S	0.80	S
	2	0.56	S	-0.24	S	0.07	S	-0.59	S	1.97	S	-1.15	S
	3	-0.56	S	-2.18	P	0.22	S	-0.20	S	0.07	S	-0.46	S
	4	1.55	S	1.15	S	-0.07	S	1.20	S	-2.22	P	1.72	S
	5	-0.64	S	2.85	P	-1.52	S	1.33	S	0.00	S	0.46	S
	6	-4.08	U	-0.30	S	-1.81	S	-0.72	S	0.00	S	-0.69	S

Where S refers to satisfactory, P refers to problematic, and U refers to unsatisfactory.

Table 5 Statistical Results of Test Data in Percentages

Testing item	1#						3#						4#					
	Satisfactory		Problematic		Unsatisfactory		Satisfactory		Problematic		Unsatisfactory		Satisfactory		Problematic		Unsatisfactory	
	N	P (%)	N	P（%）	N	P（%）	N	P (%)	N	P（%）	N	P（%）	N	P (%)	N	P（%）	N	P（%）
Cooling capacity	6	100	0	0	0	0	5	83.33	1	16.67	0	0	5	83.33	0	0	1	16.67
Cooling input power	5	83.33	0	0	1	16.67	5	83.33	0	0	1	16.67	4	66.67	1	16.67	1	16.67
EER	5	83.33	1	16.67	0	0	5	83.33	0	0	1	16.67	6	100	0	0	0	0
Heating capacity	6	100	0	0	0	0	6	100	0	0	0	0	6	100	0	0	0	0
Heating input power	5	83.33	1	16.67	0	0	4	66.67	0	0	2	33.333	5	83.33	1	16.67	0	0
COP	6	100	0	0	0	0	6	100	0	0	0	0	6	100	0	0	0	0

Where N refers to number, and P refers to percentage.

Table 6 Distribution of Test Result Types by Test Item

Sample No.	Satisfactory(%)	Problematic(%)	Unsatisfactory(%)
Cooling capacity	88.89	5.56	5.56
Cooling input power	77.78	11.11	11.11
EER	88.89	5.56	5.56
Heating capacity	100.00	0.00	0.00
Heating input power	77.78	11.11	11.11
COP	100.00	0.00	0.00

Table 7 Distribution of Test Result Types by Laboratory

Lab No.	Satisfactory(%)	Problematic(%)	Unsatisfactory(%)
1	100.00	0.00	0.00
2	88.89	0.00	11.11
3	83.33	16.67	0.00
4	88.89	5.56	5.56
5	88.89	5.56	5.56
6	94.44	0.00	5.56

I.6.3 Overall Evaluation of Round Robin Testing

I.6.3.1 The RRT Process

On one hand, under CNIS's careful organization and the strong support of participant labs, the RRT was conducted in an orderly manner. Testing results from participant laboratories were submitted on time and CLASP's international expert was briefed on the whole testing process by appointed staff. Consequently, the RRT was successfully completed and the testing data was collected on time.

On the other hand, there are more or less some aspects that can be improved, such as strengthening the safeguards measures of transporting samples to the test laboratory. The service quality of some transport companies was not satisfactory and resulted in long delays of samples. Second, the technical capabilities of personnel in some laboratory should be improved. Some laboratory staff misinterpreted the RRT implementation scheme while another faced challenges in conducting uncertainties evaluation of test results and needed some guidance and assistance. Third, some laboratories had arduous daily testing tasks and could not set aside sufficient time for the RRT. Fourth, the equipment of some laboratories needs to be better maintained and updated. Some laboratories lacked calorimeter testing capability, and the equipment of some laboratories had glitches during the RRT process.

I.6.3.2 RRT Results

As the testing items of this RRT are routine in testing laboratories' regular energy efficiency testing, the RRT will reflect the actual level of participant laboratories and verify the effect of their ongoing quality control measures. From this RRT, it can be seen that the participating laboratories have established relatively comprehensive quality control system, and consistent monitoring ability is in place. However, some problematic and unsatisfactory results still exist. Therefore, much more emphasis should be placed on enhancing quality monitoring efforts, calibration and upgrading of testing equipment, and improving the testing skills and capabilities of related personnel.

I.6.3.3 RRT Overall Impacts

In this RRT of air conditioners, a relatively complete implementation scheme was developed, which lays a solid foundation for conducting similar RRT among industry laboratories, third-party laboratories and future participation in related international RRT program. The RRT has helped enhanced the communication amongst participant laboratories and improved the testing capabilities and expertise of laboratory staff. The RRT has also contributed to identifying problems and the necessary related improvements. The RRT has helped raise awareness of energy efficiency and RRT activities in related industries and society and has actively contributed to expanding the impact of CEELS and its effective implementation.

I.7 Proposals for Enhancing Test Laboratory Capabilities and Facilities

1. Given the RRT results, all participating laboratories should further evaluate their quality control measures, testing equipment conditions, and the skills and capabilities of personnel in order to identify problems and make the necessary corrective and preventive measures to avoid future testing errors.

2. The energy efficiency testing laboratories should pay more attention to quality control efforts and continue to effectively monitor management, equipment, staff, etc.

3. Greater emphasis should be placed on upgrading testing facilities and increasing financial resources for improving the condition of laboratory equipment.

4. Regularly organize educational activities and training in testing technologies, uncertainty analysis, etc., in order to enhance the technical capacity and expertise of related personnel.

5. Actively participate in various capacity building and verification activities organized by international organizations, national institutes and provincial and municipal authorities, such as RRT and spot check-testing. Conduct internal assessment activities such as random inspections, personnel review, equipment testing, repeatability testing, etc. to continuously improve the testing capabilities of laboratories.

6. Actively learn from international best practices through capacity building efforts with other countries.

II. International Expert Analysis of Round Robin Testing (André Pierrot)

II.1 RESULTS

The following table shows the tests performed during the RRT.

Table 8: Tests Performed During the Round Robin Test

Sample	1				2				3				4			
Method	Calorimeter		Air enthalpy		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Lab 1	OK	■	OK	OK	■	■	■	■	OK	■	OK	OK	OK	■	OK	OK
Lab 2	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK	OK
Lab 3	/	/	OK	OK	/	/	OK	OK	/	/	OK	OK	/	/	OK	OK
Lab 4	OK	OK	■	■	OK	OK	■	■	OK	OK	■	■	OK	OK	■	■
Australian lab	/	/	/	/	/	/	/	/	/	/	/	/	OK	OK	/	/

■ Missing
OK Results received

Of the 58 tests scheduled (excluding the Japan Refrigeration and Air Conditioning Industry Association JRAIA laboratory), only 43 have been performed. Failures or technical problems in some testing facilities and the failure of Sample 2 at the last laboratory explain why 15 tests (in red in the table) have not been performed.

For Laboratory 4, CNIS informed that the tests using the indoor air enthalpy method were not performed due to the operation conditions of testing equipments. Details about this failure have not been given. In addition, Laboratory 4 believes that the calorimeter method can fully represent their testing ability.

For Laboratory 1, CNIS informed that the data in heating mode for calorimeter method is missing due to problems with the equipment. During the visit to this laboratory one test in heating mode was started in the calorimeter but it could not be completed due to a failure in the humidifier of the outdoor room. The explanation given by the laboratory's responsible personnel was that the pressure in the local water distribution network was too low and out of the working range of the humidifier.

During the visit to the Laboratory 1's facilities, the tests on sample 2 could not be performed. The unit started but not its compressor. This problem could not be fixed during the visit. Another sample was installed and tested during the visit. No further notice has been received about sample 2.

The direct consequence of these failures is that we received only 2 or 3 sets of test results for each type of test (i.e., by sample, mode and test method), except for the tests performed by the Australian laboratory and the JRAIA.

The basic results delivered by the 4 Chinese testing laboratories are given in Appendix A. The results received are the average values over the measurement periods of 35 minutes. The full data sheets including 7 sets of measurement values for each test and the data curves of the entire testing process of each test are being provided by CNIS.

The declarations of uncertainties for the 4 Chinese laboratories are given in Appendix D.

Comments of any type given in this report refer to the four Chinese laboratories participating in the study. If a comment refers to the Australian or the Japanese laboratories, it is clearly indicated in the text.

II.2 ANALYSIS OF RESULTS

II.2.1 General Analysis

For all the laboratories, the average values of the test conditions fulfill the requirements of the testing standard concerning the variation allowed for the arithmetical mean values from the specified test conditions. The maximum variations are given in Table 9.

Table 9 Variations Allowed During Steady-state Cooling and Heating Capacity Tests

Readings	Variations of arithmetical mean values from specified test conditions	Maximum variation of individual readings from specified test conditions
Temperature of air entering indoor-side:		
dry-bulb	± 0,3 °C	± 1,0 °C
wet-bulb	± 0,2 °C[a)]	± 0,5 °C[a)]
Temperature of air entering outdoor-side:		
dry-bulb		
wet-bulb	± 0,3 °C	± 1,0 °C

Air volume flowrate	± 0,2 °C b) ± 5 %	± 0,5 °C b) ± 10 %
a) Not applicable for heating tests. b) Only applies to cooling capacity tests if equipment rejects condensate to the outdoor coil.		

The only exception refers to the air flow rates of the indoor units measured using the air enthalpy method for which ISO 5151 1994 requires a maximum variation of ± 5%. This point will be discussed in section II.2.6.

In the following pages, we show an abstract of the results for the capacities and efficiencies, together with the deviation of each individual measurement with reference to the average value of each parameter.

II.2.2 Methodology

There are several approaches to defining an accepted reference value for each characteristic of interest, specifically the cooling and heating capacities and the energy efficiency. This reference value is necessary to compare the results obtained by the different laboratories.

The first possibility is to use for each characteristic the value measured by a reference laboratory. For this study Laboratory 4 was chosen as reference laboratory; unfortunately this laboratory has not been able to perform the tests using the air enthalpy method so the lack of reference for this method obliges us to find another solution.

As a reasonable other possibility, we will use in this study the mean values of the population of measurements.

The mean values have been calculated for each characteristic and for each test configuration:

- sample (1 to 4),
- test mode (cooling or heating)
- test method (calorimeter room method or air enthalpy method).

Due to the low number of measurements – in some cases down to 2 measurements only – the trueness of the values obtained for each parameter is not guaranteed. The probability that the mean values obtained are close to the "true" value of the parameters increases with the number of results obtained, but it is not possible to calculate it within this study.

Each time it was possible, we have used 2 average values for each parameter: one calculated with the results of the calorimeter room method or with the results of the air enthalpy method, and a second one using the results of both test methods. As a result of this decision, in the tables of Appendices B and C "differences for each method" means that every individual result is compared with the average value obtained with all the results for the same parameter obtained with the same method, and "differences for both methods" means that every individual result is compared with the average value obtained with all the results for the same parameter obtained with both calorimeter and air enthalpy methods.

In order to use the maximum information to analyze the differences between laboratories, we have tried to calculate the latent cooling capacity for each measurement in cooling mode.

For the calorimeter method, the only available data is the vapor given by the humidifier (indoor side). We have considered that the only condensation of water inside the room was produced by the sample under test. The values obtained for the latent capacity seem to be in line with the total cooling capacities measured and with the proportion of dehumidifying capacity that can be expected for a fixed speed air conditioner (between 20% and 35% of the total cooling capacity following our experience with several thousands of tests). The only risk is to obtain an overestimated value of the latent cooling capacity if some water is condensed in the reconditioning apparatus, but it seems that this was not the case in any laboratory.

For the air enthalpy method, we have calculated the difference between the total cooling capacity and the sensible cooling capacity, calculating this last one for the air flow rate and test conditions given by the laboratories for each test. This calculation has been performed using the equations given in the ASHRAE Handbook, Chapter 6 "Psychometrics". These equations are basically the same as those given in the document "空调空气焓值法制冷量试验的不确定度评定与表示".

We have classified the comparison of the results in two groups:

I. **By sample:** We can then compare the results measured by all the laboratories. This allows us to check the differences between laboratories and between the 2 measurement methods;
II. **By laboratory:** we can check if there is any laboratory bias.

The data of $\Delta T_{\text{dry bulb}}$ for the calorimeter method in Laboratory 4 is only informative, as the air outlet temperature is measured in one point and cannot be averaged like for the air enthalpy method.

The following analysis of results is based on the differences between individual results and the corresponding average values. The small number of results for each test configuration does not allow any statistical approach such as the study of the standard deviations.

In the rest of the report, the qualitative expressions "low", "normal", "high", "very high" or "extremely high" used to describe the differences found between test results are based on our experiences with several other round robin tests in the last few years between European, Asian and Australian laboratories. All these round robin tests were performed using the calorimeter room method. It also refers to the known experience of other laboratories at the international level: it is recognized that the differences obtained by using the calorimeter room method between laboratories fulfilling the quality requirements of the standard ISO/IEC 17025 should be lower than 3% for the cooling or heating capacities. When the comment is not based on this experience with other RRT or laboratories, we indicate the reference (e.g., value of uncertainty, etc.).

In this report, when we say that a difference is higher than twice the claimed uncertainty of measurement or that a difference is not in accordance with the claimed value of the uncertainty, it means that the uncertainty of measurement is probably underestimated by the laboratories.

II.2.3 Results by Sample

The detailed results are given in II.7, Appendix B.

In this section, the maximum differences for each parameter are calculated by comparing the minimum difference to the maximum one in the column called “difference for each method” in the tables of Appendix B. For instance the first value of Table 10 (total cooling capacity with the calorimeter room method is calculated in the following way using the values given in II.6.1: 1.8% - (-1.5%) = 3.3%.

In Tables 11, 13, 15 and 17, the figures given are calculated for the tables of Appendix B as the difference between the data in row “average calorimeter method” and the row “average enthalpy method” in the column “differences for both methods”. For instance the first value of Table 11 (Total cooling capacity) is calculated in the following way using the values given in II.6.1: 0.5% - (-0.5%) = 1%.

II.2.3.1 Sample 1 Results

For sample 1, the maximum differences between the measurements in the different laboratories are:

Table 10 Maximum Differences for Sample 1

Parameter	Calorimeter method	Air enthalpy method
Total cooling capacity	3.3 %	6.3 %
Power input in cooling mode	5.3 %	2.7 %
EER	6.7 %	3.7 %
Latent cooling capacity	7.6 %	14.0 %
Airflow rate in cooling mode	-	25.0 %
Heating capacity	2.6 %	2.9 %
Power input in heating mode	3.4 %	2.6 %
COP	5.8 %	2.2 %

Air flow rate in heating mode	-	14.9 %

From Table 10, we can make the following first comments:

Total cooling capacity: for both test methods, the maximum difference is higher than twice the claimed uncertainty of measurement (around 1% for the calorimeter method and 2.3% for the air enthalpy method). The maximum difference is normal for the calorimeter method and high for the air enthalpy method.

Power input in cooling mode: for both methods, the difference is very high, and is not in accordance with the claimed value of the uncertainty (between 0.3% and 0.6%).

EER: for the calorimeter method, the difference is very high and greater than twice the claimed uncertainty (2%). For the air enthalpy method, the maximum difference is in accordance with the uncertainty (2.5%).

Latent cooling capacity: the differences are high. For the calorimeter method, they follow the same trend as the variation of the results for the total cooling capacity. The differences are higher for the air enthalpy method but they do not follow the differences in the airflow rate measurements. It is not possible to know which effect this can have on the measurement of the performances of the sample.

Airflow rate in cooling mode: the differences are extremely high. ISO 5151 requires a maximum variation of the mean value of ± 5% (see Table 9). We discuss this difference more in detail in section II.2.3.5.

Heating capacity: the differences are normal and in accordance with the claimed uncertainties (2.5% for the calorimeter method and 2.3% for the air enthalpy method).

Power input in heating mode: like for the cooling mode, the differences are high. No data is available for the uncertainty of the measurement.

COP: the differences are high for the calorimeter method and normal for the air enthalpy method. No data is available for the uncertainty of the measurement.

Airflow in heating mode: the maximum difference is very high, although less than for the cooling mode. By laboratory, the deviations from the average value follow the same tendency than in cooling mode. See section II.2.3.5 for more details.

Table 11 Differences between Test Methods for Sample 1

Parameter	Difference between methods
Total cooling capacity	1.0 %

Power input in cooling mode	0.6 %
EER	0.4%
Heating capacity	1.5%
Power input in heating mode	0.5%
COP	1.0%

The average values of the results obtained for each test method are similar.

II.2.3.2 Sample 2 Results

For sample 2, the maximum differences between the measurements in the different laboratories are:

Table 12 Maximum Differences for Sample 2

Parameter	**Calorimeter method**	**Air enthalpy method**
Total cooling capacity	2.2%	4.0%
Power input in cooling mode	1.4%	2.6%
EER	0.8%	1.4%
Latent cooling capacity	14.2%	11.6%
Airflow rate in cooling mode	-	22.2%
Heating capacity	1.2%	0.4%
Power input in heating mode	0.8%	2.2%
COP	1.8%	2.6%
Air flow rate in heating mode	-	17.6%

From Table 12, we can make the following first comments:

Main results (capacities, inputs and efficiencies): for both test methods, the maximum difference are normal and within twice the claimed uncertainty of measurement.

Latent cooling capacity: the differences are high. For the calorimeter method, they follow the same trend as the variation of the results for the total cooling capacity. For the air enthalpy method they follow a reverse trend compared with the differences in the airflow rate measurements.

Airflow rates: like for sample 1, the differences are very high and are lower in heating mode than in cooling mode.

Table 13 Difference between Test Methods for Sample 2

Parameter	Difference between methods
Total cooling capacity	-0.2%
Power input in cooling mode	-0.8%
EER	0.6%
Heating capacity	2.2%
Power input in heating mode	1.2%
COP	1.0%

Like for sample 1, the differences between the average values given by each test method are normal.

II.2.3.3 Sample 3 Results

For sample 3, the maximum differences between the measurements in the different laboratories are:

Table 14 Maximum Differences for Sample 3

Parameter	Calorimeter method	Air enthalpy method
Total cooling capacity	3.2%	5.1%
Power input in cooling mode	2.2%	2.5%
EER	5.5%	6.3%
Latent cooling capacity	9.0%	11.6%
Airflow rate in cooling mode	-	24.4%
Heating capacity	3.8%	1.3%
Power input in heating mode	0.4%	4.4%
COP	3.4%	5.2%
Air flow rate in heating mode	-	22.6%

From Table 14, we can make the following first comments:

Total cooling capacity: for both test methods, the maximum difference is higher than twice the claimed uncertainty of measurement (around 1% for the calorimeter method and 2.3% for the air enthalpy method).

Power input in cooling mode: for both methods, the difference is high and is not in accordance with the claimed value of the uncertainty (between 0.3% and 0.6%). Nevertheless, the difference for the calorimeter method is lower than for sample 1.

EER: for both methods, the difference is high, and is not in accordance with the claimed value of the uncertainty (2% for the calorimeter method and 2.5% for the air enthalpy method).

Latent cooling capacity: the differences are high. For the calorimeter method, they follow more or less the same tendency as the variation of the results for the total cooling capacity. The differences are higher for the air enthalpy method but they do not follow the differences in the airflow rate measurements.

Airflow rate in cooling mode: the differences are very high and similar to those observed for sample 1.

Heating capacity: the differences are in accordance with the claimed uncertainties (2.5% for the calorimeter method and 2.3% for the air enthalpy method).

Power input in heating mode: the difference is low for the calorimeter method and high for the air enthalpy method. No data is available for the uncertainty of the measurement.

COP: the differences are high for both methods. No data is available for the uncertainty of the measurement.

Airflow in heating mode: the maximum difference is very high, although less than for the cooling mode. By laboratory, the variations from the average value follow the same trend as cooling mode.

Table 15 Differences between Test Methods for Sample 3

Parameter	Difference between methods
Total cooling capacity	0.6%
Power input in cooling mode	-0.8%
EER	1.4%
Heating capacity	3.9%
Power input in heating mode	0.0%
COP	3.8%

The differences for the heating capacity and the COP seem high, taking into account that these are the differences between average values. For a MEPS policy, a difference around 4% for COP between two test methods seems excessive.

II.2.3.4 Sample 4 Results

For sample 4, the maximum differences between the measurements in the different laboratories are:

Table 16 Maximum Differences for Sample 4

Parameter	Calorimeter method	Air enthalpy method
Total cooling capacity	7.9%	0.6%
Power input in cooling mode	3.2%	3.9%
EER	7.0%	4.4%
Latent cooling capacity	32.6%	30.1%
Airflow rate in cooling mode	-	19.9%
Heating capacity	1.0%	3.6%
Power input in heating mode	5.4%	4.1%
COP	5.1%	4.4%
Air flow rate in heating mode	-	21.0%

The maximum differences are particularly high for all parameters except the cooling capacity for the air enthalpy method and the heating capacity for the calorimeter method. In general, comments given for sample 1 apply with a special attention to the estimated latent capacity which presents very high differences for both test methods.

Table 17 Differences between Test Methods for Sample 4

Parameter	Difference between methods
Total cooling capacity	1.2%
Power input in cooling mode	-0.9%
EER	1.8%
Heating capacity	0.4%
Power input in heating mode	-0.8%
COP	0.4%

Like for sample 1, the differences between the average values given by each test method are normal.

II.2.3.5 Conclusions on Results by Sample

The following table shows the maximum differences observed for each parameter and for each test method. Each figure is the greatest of the values given in Table 10, Table 12, Table 14, and Table 16.

Table 18 Overall Maximum Differences for the Four Samples

Parameter	Calorimeter method	Air enthalpy method
Total cooling capacity	7.9%	6.3%
Power input in cooling mode	5.3%	3.9%
EER	7.0%	6.3%
Latent cooling capacity (*)	14.2%	14.0%
Airflow rate in cooling mode	-	25.0%
Heating capacity	3.8%	3.6%
Power input in heating mode	5.4%	4.4%
COP	5.8%	5.2%
Air flow rate in heating mode	-	22.6%

(*) for the latent cooling capacity, the results for sample 4 have not been taken into account because the data given by the Laboratory 1 are probably misprinted.

The differences observed are high for the cooling and heating capacities and for the energy efficiencies (see II.2.2). A difference of 7% difference in the EER may change the energy efficiency class of an air conditioner.

The high differences for the electrical inputs are probably not due to the measuring devices themselves, as all laboratories use the same high quality apparatus. Therefore, deviations are more likely to come from differences in the installation and settings of the sample and/or differences in test conditions not reflected by the readings of the air sampling devices (see section II.3 for some examples).

The differences observed for the latent cooling capacities may come from the method we used to indirectly estimate the value of this parameter (see II.2.1). Without direct data from the laboratories, it is difficult to reach any conclusion about this point. These differences may have little effect on the final results of the EER, but they indicate that the measurement of the dehumidifying capacity has to be improved.

More difficult to explain are the differences for the airflow rate. Among the possible causes for these differences, the most common are:

- Error in individual measurements. Errors due to the measuring instruments themselves are unlikely to happen.
- Errors in the calculation of the air flow. This is unlikely to happen in laboratories recognized by CNIS. We have performed the airflow rate calculations using the data given by the laboratories and the small differences obtained can be explained by the lack of data about the air temperature at the nozzle’s neck. We have used the air temperature measured at the outlet of the indoor unit because it was the only one available, and the laboratories have used the temperature at the nozzles which can be a few degrees different from the first one.

- Volume flow given for different air densities. The differences in the air densities between similar results can explain up to 3% difference, mainly due to the difference of atmospheric pressures (from 100 kPa to 103 kPa approximately between the different tests).
- Air flow losses between the sample and the airflow measuring device. This may happen but it can be checked only with a specific tightness test (see II.3.3.2.2).
- The indoor fan speed of the sample is not set to the same speed during the different tests. This is unlikely to happen for trained laboratory technicians. For the tests performed during the visits, the setting of the fan speed was the right one (high speed).
- The horizontal and/or vertical louvers at the air outlet were not in the same position during the tests in the different laboratories. This is a possibility, as these positions were not specified in the RRT document. Nevertheless, small differences in these positions should not lead to such a big difference in the airflow rate. Some differences were observed during the visits (see section II.3).
- Problems due to the installation of the duct and/or to the measurement of the static pressure difference. This is the more realistic possibility: the laboratory measures a difference of 0 Pa but in reality the fan of the airflow measuring device is “helping” or “blocking” the normal airflow of the sample. Some differences have been observed between the different laboratories (see II.4).

The values of the air outlet temperatures and the details of the airflow rate measurements (nozzles dimensions, pressure difference at the nozzles, etc.) seem to indicate that the airflow rate is actually well measured but some results are obviously very different from the standard airflow rate of the samples for free discharge. As mentioned before, it is not possible to know the “true” value of the airflow rate due to the small number of measurements so it is not possible to know which results are different from the free discharge airflow rate of the samples.

Nevertheless the limited differences for the cooling and heating capacity do not show differences that could have been expected with so great of a difference in the air flows. It is possible that the differences are within the uncertainty of the measurement observed during this round robin test and then the effect of the airflow rate differences cannot be separated from the other sources of uncertainties. The simulation presented in II.2.6 shows it may be the case for this round robin test.

From the results sorted by sample it is not possible to reach a satisfactory explanation for these differences in the airflow rate measurements. Another round robin test designed to assess the measurement of the airflow rate for non-ducted units would be necessary to identify the reasons for the differences and solve the problem.

II.2.4 Results by Laboratory

The detailed results are given in II.8, Appendix C.

It is important to remember that the results of each laboratory are compared with the average values obtained during the RRT for each parameter/method. The differences with the "true" values of the parameters might differ.

In this report, when we say that a parameter is under evaluated, we mean that the mean value of the measurements of a laboratory is lower than the average value calculated for all the laboratories.

The data given in Table 19 to Table 22 are the same as in Appendix C, row "Average", column "Differences for each method".

II.2.4.1 Laboratory 1

Table 19 Average Differences for Laboratory 1

Parameter	Calorimeter method	Air enthalpy method
Total cooling capacity	-0.6%	-0.9%
Power input in cooling mode	1.5%	0.4%
EER	-2.1%	-1.3%
Latent cooling capacity	-8.1%	-8.8%
Airflow rate in cooling mode	-	4.0%
Heating capacity	-	-0.8%
Power input in heating mode	-	0.4%
COP	-	-0.9%
Air flow rate in heating mode	-	3.8%

The EER determined using the calorimeter method appears to be under-evaluated, although it is not the case for sample 4 (see Appendix C).

The latent cooling capacity seems also to be under evaluated. The greatest deviation is for sample 4. We have not enough information to know if these differences may have an effect on the final results.

The airflow rate is very close to the average value, except for sample 4 where it is 12% greater than the mean value. This means that the dimensions of the duct installed between the indoor unit and the discharge plenum and the installation of this duct may have an influence on the measurement of the air flow.

There are no particular comments for other parameters.

II.2.4.2 Laboratory 2

Table 20 Average Differences for Laboratory 2

Parameter	Calorimeter method	Air enthalpy method
Total cooling capacity	0.8%	2.4%
Power input in cooling mode	-0.8%	0.1%
EER	1.6%	2.2%
Latent cooling capacity	7.0%	1.4%
Airflow rate in cooling mode	-	7.2%
Heating capacity	-1.1%	-0.3%
Power input in heating mode	0.5%	-1.1%
COP	-1.5%	0.7%
Air flow rate in heating mode	-	4.5%

For the air enthalpy method, the total cooling capacity and the EER seem to be slightly over evaluated (+2.4% compared with the average values of all the laboratories).

Latent cooling capacity seems to be over evaluated for the calorimeter method. It presents big variations for the air enthalpy method (from -5.8% to +14.7% depending of the sample). This has not a direct effect on the final result of the EER, but shows that some problems have occurred during these measurements.

The airflow rate seems over evaluated, although the difference between models of indoor unit is very important: in cooling mode +12% for samples 1 to 3 and -7% for sample 4. The tendency is the same in heating mode. As for Laboratory 1, this means that the dimensions of the duct installed between the indoor unit and the discharge plenum and the installation of this duct may have an influence on the measurement of the air flow. See II.2.6 for more discussion about this subject.

There are no particular comments for the other parameters.

II.2.4.3 Laboratory 3

Table 21 Average Differences for Laboratory 3

Parameter	Calorimeter method	Air enthalpy method
Total cooling capacity	-	-1.7%
Power input in cooling mode	-	-0.4%

EER	-	-1.2%
Latent cooling capacity	-	5.2%
Airflow rate in cooling mode	-	-10.1%
Heating capacity	-	0.9%
Power input in heating mode	-	0.8%
COP	-	-0.1%
Air flow rate in heating mode	-	-7.4%

The latent cooling capacity seems to be slightly over estimated. In the case of this laboratory, it may be related to the lower values of the airflow rates. In Table 23, the simulation shows that the dehumidifying capacity may be lower for higher airflow rates.

The airflow rate seems under estimated, in a different proportion according to the model of indoor unit. Once again, this shows that the shape of the duct and its installation seems to have a big influence on the airflow rate measurement.

There are no particular comments for the other parameters.

II.2.4.4 Laboratory 4

Table 22: Average Differences for Laboratory 4

Parameter	Calorimeter method	Air enthalpy method
Total cooling capacity	0.4%	-
Power input in cooling mode	-0.4%	-
EER	0.8%	-
Latent cooling capacity	-0.9%	-
Airflow rate in cooling mode	-	-
Heating capacity	1.0%	-
Power input in heating mode	-1.1%	-
COP	2.1%	-
Air flow rate in heating mode	-	-

The COP seems to be over evaluated by this laboratory, but the tendency is not clear as +2.1% is still within the differences found for other round robin tests and we cannot conclude that it is a permanent deviation from the average value calculated with all the laboratories. We would need more test results to confirm or deny a difference.

There are no particular comments for the other parameters.

II.2.4.5 Conclusions on Results by Laboratory

Some final results seem to be under or over evaluated, but the average differences in these cases are close to 2% which is still a reasonable value and similar to the differences found in other round robin tests. Further comparison tests would be necessary to confirm these tendencies. Periodic round robin tests are required by ISO/IEC 17025 and further results may help to confirm if there are differences statistically significant. Nevertheless, the laboratories which seem to present systematic differences should revise their testing procedures and facilities in order to determine if some measurements can be improved.

The main differences appear once again for the airflow rates measured with the indoor air enthalpy method. More than the average differences themselves, the main comments are about the very different behavior of this measurement according to the type of indoor unit. Samples 1 to 3 are of the same model, and in the same laboratory the duct used for these 3 samples is always the same, as observed during the visits of the laboratories. The difference between the individual results and the average values are very similar for these three samples, but can be very different for sample 4 for which another duct has been used.

From one model of indoor unit to the other, the only difference in the test installation for the air enthalpy method is the shape of the duct fitted between the indoor unit and the plenum where the outlet air conditions (dry and wet bulb temperatures) are measured. Some pictures of the ducts and pressure measurement positions used by each laboratory are given in II.3.This fact may indicate that the measurement of the static pressure at the outlet of the indoor unit is not performed in a satisfactory way, and then that the fan of the airflow rate measuring apparatus is modifying the airflow rate of the sample.

The effect of this problem on the final results (EER and COP) is discussed in II.2.6.

II.2.5 Conclusions on Test Results

The results of the round robin test concerning the EER and the COP measurements do not show extreme deviations. A deviation can be considered extreme if the differences are much greater than twice the known uncertainty of the measurement method.

The European standard EN 14511 requires a maximum uncertainty of 5% for the calorimeter method and of 10% for the indoor air enthalpy method. These values are an expanded uncertainty of measurements expressed at the 95% level of confidence. The revision of ISO 5151 currently under work also gives the same limits.

The maximum deviation from the medium value for the capacities is 2.4%, and 2.2% for the efficiencies. These deviations are in agreement with the maximum uncertainty of measurement required by the testing standards. The maximum differences between laboratories are lower than 7.9% for the capacity measurements and lower than 7.0% for the energy efficiencies, which is also in agreement with ISO 5151:1994 (less than twice the required uncertainty). These deviations include not only the uncertainty of the measurement itself, but also the effect of the differences in the installation of the samples.

No significant difference has been observed between the average capacities and efficiencies measured by the calorimeter method and the air enthalpy method, although it is known that the uncertainty is higher for the indoor air enthalpy method than for the calorimeter method. This point is developed in II.4. The differences in the airflow rate measurements also show that the results obtained using the air enthalpy method should be used with care.

A maximum difference of 25.0 % has been observed for the airflow rate measured by different laboratories for the same indoor unit. Unfortunately, as described before, it has not been possible to find an explanation to this difference. It seems logical to conclude that there is a problem in the measurement of the static pressure at the outlet of the indoor units, but the final results do not show big differences.

To try to reach a preliminary conclusion, we have used a commercial simulation software used for the design of new models. The results have been obtained for a large air/air split heat pump and are shown in Table 23.

Table 23 Simulation for a Difference of ±10% in the Indoor Airflow Rate

Airflow rate indoor	**90%**		**100%**		**110%**	
Mode	*COOLING*	*HEATING*	*COOLING*	*HEATING*	*COOLING*	*HEATING*
Cooling or heating capacity (%)	98,2%	99,5%	100,0%	100,0%	101,1%	100,3%
Dry bulb, air outlet (ºC)	13,8	38,8	13,8	37,0	13,8	35,5
Dehumidifying capacity (%)	25,5%	-	22,9%	-	20,9%	-
EER/COP	3,2	4,1	3,2	4,2	3,2	4,4

The simulation shows that the differences are not very important. For instance between the two extreme airflow rates (20% difference between the flow rates):

- Difference for the total cooling capacity: 3%
- Difference for the EER: none
- Difference for the heating capacity: 1%
- Difference for the COP: 7%

These differences are within the uncertainty of the measurements for the air enthalpy method and this may explain why we have not found any tendency for variation of the results in function of the airflow rate differences. Nevertheless, we have determined that the differences in the airflow rate were real and that differences similar to those given by the simulation should have been observed. From this simulation, we can see it is highly probable to measure the COP with an unacceptable uncertainty if the problems of measurements of the airflow rate are not solved.

Finally, the results by laboratory do not show a tendency about a possible degradation of the performances of the samples after several installations, tests and transports.

II.3 EVALUATION OF THE TEST FACILITIES

II.3.1 General Comments

During the round robin test, a visit was organized to witness the tests and to assess the testing facilities and the test procedures used by each laboratory.

These visits were attended by the responsible persons of each laboratory and by a person from CNIS. Each time that it was possible, one test in cooling mode and one in heating mode were performed during the visit for each test method covered by the laboratory. Both test methods were observed in Laboratory 1 and 2. Only the calorimeter method was observed in Laboratory 4 although the facility used for the indoor air enthalpy method could have been visited. Laboratory 3 only uses the air enthalpy method.

In general, the design and quality of the test facilities are satisfactory and in accordance with the requirements of the testing standard. In general, the measuring devices, their precision and their calibration are satisfactory and in accordance with the requirements of the testing standard. Some deviations have been observed during the visits and are explained for each laboratory, as well as some observations. In II.3.1, we describe the points that refer to the four laboratories and in II.3.2, we specify some comments particular to each laboratory. We also describe with more details the measurement of some parameters when they are performed in different ways by the laboratories (see II.3.2).

Another issue that will require some improvements is the installation of the sample itself. For instance in three of the laboratories, the tests have been performed with some parts of the refrigerant piping without thermal insulation (see the photos below).

Figure 5 Refrigerant Piping Without and With Thermal Insulation

The effect on the capacity is small but, together with all the small details that have to be considered during the installation of the samples, it can make the difference between a “Passed” or “Not Passed” result within a MEPS program.

During the visit, it was not possible to check the refrigerant charging procedures in all the laboratories but nevertheless some disconformities have been detected. For example, removing hoses still containing refrigerant in liquid phase after the charging lead to a greater leakage than when the hose is removed with refrigerant in gas phase or if a quick connect/disconnect sealing valve is used.

Also related to the settings of the samples is that the lack of clear criteria about the position of the horizontal vane or louver at the air outlet of the indoor unit in some laboratories. In some cases, this position was not exactly identical for the same sample tested by the same laboratory with both calorimeter and air enthalpy methods. In particular, some settings of this vane of the indoor unit were not in a position giving the maximum airflow rate, in contradiction with clause 4.1.4.1.d) of ISO 5151:1994.

The impact on the air flow with free air discharge should not be very important but the sum of all the small details we are describing in this part of the report may together change a pass/not passed result if the performance of the unit under test are very close to the limit defined in a MEPS.

For the measurement of the air temperature and humidity conditions, most of the laboratories are using a double measurement for the dry and wet bulb in order to ensure the quality of the measurements, except Laboratory 1 where only one measurement device is used for each parameter. The use of a second measurement helps detect quickly any potential problems in the measurement of the test conditions. The flexible ducts used to transport the air sampled at the inlet of the indoor or outdoor units to the temperature measurement devices is generally insulated, except in Laboratory 3. The temperature is generally not perfectly uniform within the room and can have a small effect on the temperatures actually measured if this duct is not properly insulated.

Regarding the calorimeter room test method, all the laboratories using this method have a balanced ambient room type calorimeter, which the better solution for this method.
The maximum test capacity varies with the dimensions of the rooms between 7 and 14 kW. These calorimeters follow the requirements of the testing standard except the oldest one (Laboratory 1) which is not measuring the air temperature conditions at the location specified by the standard. It is important to note that this laboratory will change its location and build new facilities in 2010.The control of the test conditions is not performed exactly in the same way by all the laboratories, but it fulfills the maximum tolerances required by the testing standard in every case.

The condensate flow rate in cooling mode is generally not measured directly at the condensate outlet of the indoor unit, but rather estimated by measuring the water flow rate entering the humidifying apparatus. This measurement is made using weight or volume difference as a function of the time. There is a possibility of error in the measurement if part of the vapor is condensed in the reconditioning apparatus of the room and not by the sample under test. Laboratory 4 is the only laboratory to also perform a direct measurement of the condensate flow rate.

For the calculation of the heat exchange through the walls of the rooms of the calorimeters, all the laboratories use the measurement of the temperatures of both sides of the walls in several points (up to 9 positions for a wall) using thermocouples. The heat exchange coefficient is generally calculated by the laboratories using data given by the supplier of the calorimeter, except for Laboratory 2 which declares performing a calibration of this coefficient following the method given in clause B.4.3 of ISO 5151:1994. Both possibilities (calculation or calibration) are allowed by the testing standard although the calibration is more accurate.

The thermocouples used for the wall temperatures are generally embedded in the wall near the surface and are not easily removable. They are not calibrated as temperature measurement devices although the corresponding channels of the data acquisition system are verified periodically. This calibration should be performed periodically as for the other measurement devices, although it is much more important to perform a good calibration of the heat transfer coefficient of the walls.

In regards to the indoor air enthalpy test method, the facilities of the different laboratories are designed for maximum capacities between 12 and 80 kW. All of them are able to fulfill the test condition requirements of the standard. The main difference observed during the visits is the way to connect the unit to the plenum where the wet and dry bulb air temperatures at the outlet are measured, and where the static pressure (ESP) is measured. The length of the duct varies from a laboratory to another for the same sample and the position of the pressure taps used to measure the ESP may be in the same duct or in the discharge plenum.

II.3.2 Comments on Individual Laboratories

II.3.2.1 Laboratory 1

As mentioned before, this is the oldest of the four laboratories. In 2010, new facilities will be built which will solve the differences observed during the visit and which we describe below.

This laboratory uses calorimeter and air enthalpy methods in different facilities.

For the air enthalpy method, the duct between the indoor unit air outlet and the discharge plenum is short and the measurement of the ESP is performed in 4 points at the end of the duct, just before entering the discharge plenum (see Figure 6).

Figure 6 Air Enthalpy Method at Laboratory 1

This position of the ESP measurement is not correct. It should be done in the discharge plenum or in a longer straight length of the duct (see II.3.3.2.2). At the position used by Laboratory 1, there is no guarantee that the air flow is uniform.

The calorimeter used for this study presents a difference compared with the other laboratories and not in agreement with the testing standard: the measurement of the air inlet conditions indoor side is performed at the outlet of the reconditioning apparatus which is situated about 1.5 m from the indoor unit (see Figure 7).

Figure 7 Indoor Room Air Sampling

In order to evaluate the possible difference between the dry bulb temperature measured by the laboratory and the actual dry bulb temperature at the inlet of the indoor unit, two thermocouples have been placed during the test in cooling mode near the air inlet. During the visit, the temperatures measured by these thermocouples were between 0.1 K and 0.3 K below the temperature measured at the outlet of the reconditioning apparatus. This difference can have a small effect on the capacity measured.

The position of the air sampling apparatus also results in the use of a position of the vane at the air outlet which does not correspond to the maximum air flow (see Figure 7).

The coefficient of heat exchange through the wall is calculated. It should be calibrated.

II.3.2.2 Laboratory 2

Both calorimeter and air enthalpy methods are used in the same two-room facility.

For the air enthalpy method, the duct between the indoor unit air outlet and the discharge plenum is long and the measurement of the ESP is performed in 4 points at the end of the duct, just before entering the discharge plenum (see). This measurement position seems to fulfill the conditions required for ducted units in the revision of ISO 13253 and we consider it as one of the right ways to measure the ESP (the length of the duct is a minimum of $2.5\times\sqrt{\left(4\times\left(A\times B\right)\div\pi\right)}$ where A = width and B = height of duct. Static pressure readings are taken at a distance of $2\times\sqrt{\left(A\times B\right)}$ from the outlet).

Figure 8 Air Enthalpy Method at Laboratory 2

For the calorimeter method, the coefficient of heat exchange through the wall is calibrated, which is the best solution for this parameter.

II.3.2.3 Laboratory 3

This laboratory uses only the indoor air enthalpy method.

For the air enthalpy method, the duct between the indoor unit air outlet and the discharge plenum is short and the measurement of the ESP is performed in 4 points in the first section of the discharge plenum (see figure below).

Figure 9 Air Enthalpy Method at Laboratory 3

The measurement of the ESP in the plenum is one of the correct ways to measure, and it also allows the use of short ducts.

The air sampling device is placed at about 50 cm from the air inlet of the outdoor unit, which seems excessive and may leads to small differences in the air conditions measurements if they are not perfectly uniform in that part of the room.

Figure 10 Air Sampling Outdoor Side at Laboratory 3

II.3.2.4 Laboratory 4

This laboratory uses calorimeter and air enthalpy methods in different facilities, and only the calorimeter method has been used for this study.

In regards to the air enthalpy method, we want to mention that the duct between the indoor unit air outlet and the discharge plenum is short and the measurement of the ESP is performed in 4 points in the first section of the discharge plenum.

Like for Laboratory 3, this position of measurement of the ESP is correct.

Concerning the calorimeter method, this laboratory is the only one measuring directly the condensate flow rate using a weight gauge. This is the best way to perform this measurement.

The coefficient of heat exchange through the wall is calculated. It should be calibrated.

II.3.3 Guidelines to Improving Quality of the Tests

II.3.3.1 Installation of the Samples

As mentioned before, some small incidences have been found during the visit concerning the installation of the sample. It is necessary to remember that including the smallest details may have an influence on the final result and that it is responsibility of the testing laboratory to install the unit in the way required by the testing standard.

Two points about the installation of the sample can be highlighted:

- Insulation of the refrigerant piping: the refrigerant pipes should be insulated, including the pipes' connections. If the corresponding accessories are delivered with the sample then they should be used; if not, the laboratory should provide the insulation. If provided by the laboratory, the polyethylene foam should have a minimum thickness of 6 mm. The gas and liquid pipes should be insulated separately.

- In the case where the refrigerant has to be refilled, special care should be given to the whole process to ensure that there is no leakage during the charging. Special care shall be given at the end of the process when the charging hose has to be removed from the service valve. This can be achieved by using quick connect/disconnect sealing valves or by removing the charging hoses with the sample running in cooling mode so the refrigerant is in gas phase at low pressure in the zone of the service valve to which the charging hose is connected.

The testing procedures of the laboratories should be revised to include the details of the installation of the samples and to highlight that the requirements for an installation in a testing laboratory are greater than for a standard installation in a house.

About the settings of the sample for the tests, some points are critical. Clause 4.1.4.1.d) of ISO 5151:1994 says: “Grille positions, damper position, fan speeds, etc. shall be set to result in maximum cooling capacity unless this is contrary to the manufacturer’s instructions”. This means that for non-inverter samples, the following settings shall in general be used:

- Grilles, dampers, vanes, louvers should be placed in a position where the airflow rate is the greatest. If the position of maximum airflow rate is not given by the manufacturer, a possible criterion is to place these accessories in a position where the pressure drop is minimum, i.e. parallel to the air flow and/or to the border surfaces of the air outlet. When using the air enthalpy method, the laboratory should be able to check the position of these accessories after closing the duct (for instance with a transparent windows).

- Fan speed should be set to the highest one. This means that if some special function like “Turbo”, “Boost”, “Powerful” or similar is permanent (i.e., does not come back automatically to high speed after a certain time), it should be used for the tests.

- When performing test in heating mode, the highest room temperature should be set with the control device of the sample. When performing measurements in cooling mode, the lowest room temperature should be set with the control device.

For inverter samples, the above instructions are also to be followed, unless the manufacturer gives a special starting procedure to set the nominal frequency of the compressor. In this last case the instructions of the manufacturer supersede the standard procedure. For inverter samples, it is recommended to start the unit with temperature conditions close to the test conditions. In many occasion this is part of the special starting procedure given by the manufacturers.

II.3.3.2 Test Facilities

Most of the following comments are general and not directly related to observations made during the visits to the laboratories, other have been commented in II.3.2 and are given to improve some situations observed during the visits.

II.3.3.2.1 Calorimeter Room Method

Some advice is given in order to improve the quality of the tests using the calorimeter method:

- Position of the air samples: the air samplers should be placed at short distance from the air inlet for both indoor and outdoor units. The distance between the air sampler and the air inlet should be between 0.10 m and 0.15 m.

- The flexible ducts between the air samplers and the temperature measurement locations should be insulated.

- The heat transfer coefficients of the walls of the rooms should be calibrated. Differences of up to 15% between the calculated values and the calibrated ones have been found in some European laboratories. The wall temperature measuring instruments should be calibrated, especially if thermocouples are used.

- The condensate flow rate should be determined at the condensate outlet of the indoor unit in cooling mode.

- Double checks should always be performed for measurements of the dry and wet bulb temperatures. Dry bulb temperature should be checked with another dry bulb temperature measurement. Wet bulb can be checked with another wet bulb temperature measurement, with a dew point temperature measurement or with a good relative humidity measurement.

- In cooling mode it is not necessary to control the outdoor air humidity for split units. To do so will increase the uncertainty of the measurement of the total capacity performed in the outdoor compartment and thus the criteria of 4% maximum difference between the two measurements of the cooling capacity may fail more frequently.

II.3.3.2.2 Indoor Air Enthalpy Method

Several points should be taken into account for the tests using the indoor air enthalpy method:

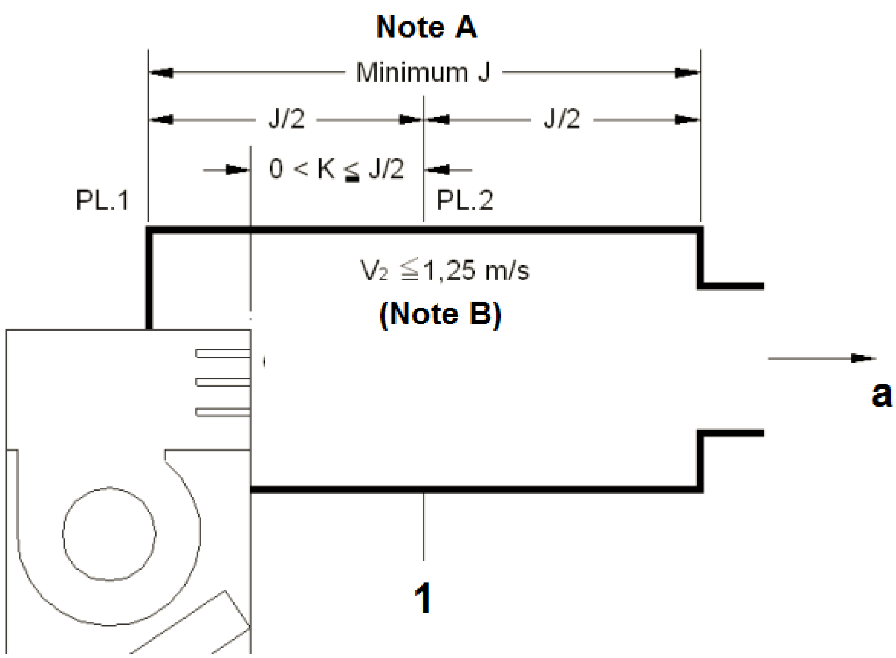
The measurement of the condensate flow rate should be always performed at the condensate outlet of the indoor unit in cooling mode and the corresponding value of the humidifying capacity compared with the value given by the air enthalpy calculation. This allows detecting quickly possible air leakages or measuring instrument failures. This also allows detecting problems in the wet bulb temperature measurement performed at the outlet of the indoor unit: in most of the cases the outlet air is nearly saturated and the measurement close to the saturation curve is more difficult.

It is recommended to perform periodically a check of the air tightness of the airflow rate measuring apparatus. This can be done by closing the duct where the indoor unit is connected and measuring the leakage air flow rate with a very small nozzle with the fan of the airflow measuring apparatus at full speed. The maximum value of this leakage should be determined for each facility.

The measurement of ESP to adjust the free air discharge condition for the indoor unit should be performed preferably in the discharge plenum. If the measurement is performed in the duct, it should verify the following requirements: the length of the duct shall have a minimum value of $2.5 \times \sqrt{(4 \times (A \times B) \div \pi)}$ where A = width and B = height of duct, and static pressure readings shall be taken at a distance of $2 \times \sqrt{(A \times B)}$ from the outlet. This will avoid accidental measurement of dynamic pressure instead of static pressure.

It is to be noted that a third possibility is being developed within the revision of ISO 5151 (see Figure 11)

Figure 11 Discharge Chamber Requirements for Indoor Air Enthalpy Test Method



1 static pressure tappings
a to air sampler and airflow measuring apparatus.

Note A: J=2.D_e where $D_e = \sqrt{(4 \times (A \times B) \div \pi)}$. A and B are the dimensions of the equipment's air outlet.

Note B: V_2 is the average air velocity at PL.2.

II.4 COMPARISON WITH JRAIA LABORATORY RESULTS

The results obtained by the JRAIA laboratory have been received at the end of the project.[2]

The tests performed include the following ones:

Sample	1				2				3				4			
Method	Calorimeter		Air enthalpy		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
JRAIA									OK	OK	OK	OK	OK	OK		

For sample 3, the comparison with the average values of the results obtained by the Chinese laboratories is as follows:

Table 24 Comparison of Results in Cooling Mode for Sample 3

SAMPLE 3	Results			
COOLING MODE	**Capacity**	**Input**	**EER**	**Latent**
Average calorimeter method	3 639	1 317	2.76	895
JRAIA calorimeter method	3 548	1 307	2.71	1 046
Difference (%)	**-2.5%**	**-0.8%**	**-1.8%**	**16.9%**
Average air enthalpy method	3 614	1 328	2.72	
JRAIA air enthalpy method	3 512	1 315	2.67	
Difference (%)	**-2.8%**	**-1.0%**	**-1.9%**	

[2] For the full report of the JRAIA testing results, see the Japan Refrigeration and Air Conditioning Industry Association's report, "Support for Activities on Enhanced Test Techniques of Testing Laboratories of Air Conditioning Equipment in Vietnam and China" (in Japanese).

Table 25 Comparison of Results in Heating Mode for Sample 3

SAMPLE 3	Results		
HEATING MODE	**Capacity**	**Input**	**COP**
Average calorimeter method	3 954	1 212	3,27
JRAIA calorimeter method	3 706	1 255	2,95
Difference (%)	**-6.3%**	**3.6%**	**-9.6%**
Average air enthalpy method	3 804	1 211	3,14
JRAIA air enthalpy method	3 814	1 246	3,06
Difference (%)	**0.3%**	**2.9%**	**-2.6%**

The results in cooling mode are within tolerances but seem to show that the sample was maybe tested with less refrigerant charge than in China. Nevertheless, the results in heating mode do not confirm this hypothesis (higher electrical input).

In heating mode the difference is greater for the calorimeter method. No explanation has been found to explain this difference. The result for the heating capacity may be due to a lack of refrigerant, but in this case the electrical input should also be lower than the average value. In heating mode the difference between the results of heating capacity using the calorimeter or the air enthalpy method is 2.9%.

For sample 4, the comparison with the average values of the results obtained by the Chinese laboratories is as follows:

Table 26 Comparison of Results in Cooling Mode for Sample 4

SAMPLE 4	Results			
COOLING MODE	**Capacity**	**Input**	**EER**	**Latent**
Average calorimeter method	4 904	1 815	2.70	1 103
JRAIA calorimeter method	4 200	1 719	2.44	1 004
Difference (%)	**-14.4%**	**-5.3%**	**-9.5%**	**-9.0%**

Table 27 Comparison of Results in Heating Mode for Sample 4

SAMPLE 4	Results		
HEATING MODE	**Capacity**	**Input**	**COP**
Average calorimeter method	5 548	1 767	3.14
JRAIA calorimeter method	5 276	1 790	2.95
Difference (%)	**-4.9%**	**1.3%**	**-6.1%**

The results in cooling mode are very low, particularly the cooling capacity. Possible causes are a lack of refrigerant or a problem with the four ways valve of the sample, or another type of failure of the sample. The difference is much less in heating mode, making the hypothesis of insufficient refrigerant difficult to confirm.

The differences observed for sample 4, and also for sample 3 in heating mode, seem too high to be explained by a laboratory bias. Differences in the refrigerant charges are not confirmed by all the results (electrical inputs). A possible explanation is that the samples have suffered some damage during the transport. Further round robin testing would be necessary to reach a conclusion.

II.5 CONCLUSIONS OF THE STUDY

The main conclusions of the studies are the following ones:

- The Chinese independent laboratories which have participated in the round robin testing show a good level of quality for the measurement of the energy efficiencies of air/air air conditioners and heat pumps. Some improvements may be considered for both testing methods. Some of them have been scheduled like in the case of Laboratory 1.

- The differences between the results obtained by the different laboratories are compatible with the maximum uncertainty of measurement for these tests, although the maximum difference of 7% obtained for the energy efficiency seems high for a MEPS system. The higher the maximum difference in the test result, the higher the possibility that the same model tested in different laboratories have different results relative to the MEPS low limits. Actions designed to reduce this difference by improving the quality of the tests should be taken. Periodic round robin tests performed on a regular basis would be the best way to check the effectiveness of the improvements and to verify that the quality of the test remains constant. Furthermore, these periodical round robin tests are mentioned in clause 5.9.1.b) of ISO/IEC 17025:2005 and are considered as a requirement by most of the accreditation bodies.

- A maximum difference of 25.0 % has been observed for the airflow rate measured by different laboratories for the same indoor unit. This difference is very high and should be carefully assessed and sorted out. A specific round robin test designed for this purpose would probably be necessary to achieve this goal.

- No significant difference has been observed between the average capacities and efficiencies measured by the calorimeter method and the air enthalpy method. This result is unexpected considering the differences in the airflow rate measurement and the fact that uncertainty calculations and experience in other parts of the world indicate that the calorimeter room method is more accurate than the air enthalpy method.

- Some improvements concerning the installation and the settings of the samples should be studied. These possible improvements are described in II.3.3.

- Additional round robin tests would be necessary to compare the results of the Chinese laboratories with those of the JRAIA laboratory.

In our opinion, it is possible to enhance the quality of the testing without excessive efforts, provided that some periodic verification is performed within the independent laboratories.

We would also like to point out that the air enthalpy method is not the best test method in a MEPS environment, as this method has a greater uncertainty of measurement than the calorimeter room method, and above all because there is no verification of the result with a simultaneous measurement outdoor side.

It is recognized by ISO and CEN that the indoor air enthalpy method is not the most appropriate method for precision measurements. In the revision of ISO 5151, a verification method is recommended if the air enthalpy method is used:

"For cooling capacity tests and steady-state heating capacity tests, a confirming test is recommended to verify the results obtained using the indoor air enthalpy test method. One of the following test methods can be used for confirming purposes:

1. *Compressor calibration method*
2. *Refrigerant enthalpy method*
3. *Outdoor air enthalpy test method*
4. *Indoor calorimeter confirming test method*
5. *Outdoor calorimeter confirming test*
6. *Balanced calorimeter confirming test method*

The results of the primary test shall agree with the results of the confirmation test within 5% to be valid."

Each verification method proposed in the previous paragraph will be described in the new version of ISO 5151.

The Annex A "Energy labeling application" of the standard EN 14511-2:2007 concerning the testing for the Energy Labeling Directive 2002/31/EC specifically indicates in its clause A.3: "*When the present standard is used for the energy labeling of air conditioners and heat pumps below 12 kW, the cooling / heating capacities, power input and EER/COP as well as the energy efficiency class of a product shall be determined by using exclusively the calorimeter room method*".

The air enthalpy method has several advantages for the development of new products, such as the lower cost of the testing facilities and the shorter time required for the tests. Nevertheless, for control with a MEPS policy, it should be reserved for units that cannot be tested using the calorimeter room method. In addition, a verification method should be used when using the indoor air enthalpy method.

II.6 APPENDIX A: BASIC RESULTS

II.6.1 Laboratory 1

Sample		1				2			
Method		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode		Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Dry bulb. air inlet. outdoor side	ºC	35.0		35.0	7.0				
Wet bulb. air inlet. outdoor side	ºC	23.5		24.0	6.1				
Dry bulb. air inlet. indoor side	ºC	27.0		27.0	20.0				
Wet bulb. air inlet. indoor side	ºC	19.0		19.0	10.4				
Dry bulb. air outlet. indoor side	ºC			13.9	38.5				
Wet bulb. air outlet. indoor side	ºC			12.7	17.8				
Atmospheric pressure	kPa	100.422		102.994	103.033				
Vapour given by the humidifyer (indoor side)	kg/h	1.282							
Indoor unit air flow rate	m3/h			585	646.2				
Pressure drop in noozles	Pa			269.7	308.3				
Diameter noozle 1	m			0.1	0.1				
Diameter noozle 2	m			0.1	0.1				
Cooling or heating capacity	W	3 626		3 541	3 861				
Power input	W	1 382		1 326	1 203				
EER or COP	W/W	2.62		2.67	3.21				

Sample		3				4			
Method		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode		Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Dry bulb. air inlet. outdoor side	ºC	35.0		35.0	7.0	34.9		35.0	7.0
Wet bulb. air inlet. outdoor side	ºC	24.0		24.0	6.0	24.0		24.0	6.0
Dry bulb. air inlet. indoor side	ºC	27.0		27.0	20.0	27.0		27.0	20.0
Wet bulb. air inlet. indoor side	ºC	19.0		19.0	11.0	19.0		19.0	13.5
Dry bulb. air outlet. indoor side	ºC			13.9	38.6			14.3	38.8
Wet bulb. air outlet. indoor side	ºC			12.6	18.0			13.4	18.0
Atmospheric pressure	kPa	102.341		102.57	102.595	102.341		99.674	99.661
Vapour given by the humidifyer (indoor side)	kg/h	1.269				1.269			
Indoor unit air flow rate	m3/h			583.2	629.1			905.4	942.3
Pressure drop in noozles	Pa			267.1	292.5			282	147.6
Diameter noozle 1	m			0.1	0.1			0.1	0.1
Diameter noozle 2	m			0.1	0.1			0.07	0.07
Cooling or heating capacity	W	3 593		3 574	3 783	4 892		4 849	5 484
Power input	W	1 335		1 348	1 216	1 813		1 831	1 823
EER or COP	W/W	2.69		2.65	3.11	2.70		2.65	3.06

II.6.2 Laboratory 2

Sample		1				2			
Method		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode		Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Dry bulb. air inlet. outdoor side	ºC	34.83	7.03	35.15	7.04	35.11	7.01	35.05	7.04
Wet bulb. air inlet. outdoor side	ºC	26.84	6.00	26.82	6.01	28.35	6.01	23.67	6.01
Dry bulb. air inlet. indoor side	ºC	26.87	19.94	27.14	19.98	27.12	19.98	26.93	19.98
Wet bulb. air inlet. indoor side	ºC	18.83	13.53	19.09	13.61	19.07	13.83	18.90	13.73
Dry bulb. air outlet. indoor side	ºC			14.70	36.61			14.67	36.82
Wet bulb. air outlet. indoor side	ºC			13.19	19.53			13.06	19.68
Atmospheric pressure	kPa	101.85	101.87	101.77	101.71	101.13	101.41	100.99	101.59
Vapour given by the humidifyer (indoor side)	kg/h	1.327				1.429			
Indoor unit air flow rate	m3/h			658	685			654	694
Pressure drop in noozles	Pa			430	489			429	492
Diameter noozle 1	m			0.05	0.05			0.05	0.05
Diameter noozle 2	m			0.08	0.08			0.08	0.08
Cooling or heating capacity	W	3 704	3 912	3 741	3 875	3 688	3 998	3 730	3 944
Power input	W	1 321	1 249	1 350	1 230	1 312	1 231	1 331	1 199
EER or COP	W/W	2.80	3.13	2.77	3.15	2.81	3.25	2.80	3.29

Sample		3				4			
Method		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode		Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Dry bulb. air inlet. outdoor side	ºC	35.04	6.99	35.00	7.02	34.84	7.03	35.03	7.03
Wet bulb. air inlet. outdoor side	ºC	23.36	6.02	23.33	6.04	20.48	6.03	21.38	6.01
Dry bulb. air inlet. indoor side	ºC	27.12	19.96	27.02	20.08	27.03	19.97	26.87	20.09
Wet bulb. air inlet. indoor side	ºC	19.05	13.81	19.02	14.03	19.04	13.09	19.03	13.20
Dry bulb. air outlet. indoor side	ºC			14.57	35.83			13.26	39.59
Wet bulb. air outlet. indoor side	ºC			13.12	19.52			12.10	20.42
Atmospheric pressure	kPa	102.1	102.16	102.21	101.36	102.47	102.12	102.43	101.98
Vapour given by the humidifyer (indoor side)	kg/h	1.388				1.796			
Indoor unit air flow rate	m3/h			660	710			745	765
Pressure drop in noozles	Pa			430	535			321	371
Diameter noozle 1	m			0.05	0.05			0.04	0.04
Diameter noozle 2	m			0.08	0.08			0.1	0.1
Cooling or heating capacity	W	3 708	3 879	3 727	3 829	4 835	5 518	4 862	5 453
Power input	W	1 306	1 209	1 321	1 182	1 781	1 769	1 794	1 749
EER or COP	W/W	2.84	3.21	2.82	3.24	2.71	3.12	2.71	3.12

II.6.3 Laboratory 3

Sample		1				2			
Method		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode		Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Dry bulb. air inlet. outdoor side	ºC			34.99	7.09			34.95	6.96
Wet bulb. air inlet. outdoor side	ºC			23.96	6.00			23.92	5.94
Dry bulb. air inlet. indoor side	ºC			26.98	20.02			26.92	19.95
Wet bulb. air inlet. indoor side	ºC			18.92	14.99			19.03	15.01
Dry bulb. air outlet. indoor side	ºC			13.31	39.91			13.42	39.97
Wet bulb. air outlet. indoor side	ºC			11.87	21.89			12.03	21.95
Atmospheric pressure	kPa			101.75	101.77			101.46	101.41
Vapour given by the humidifyer (indoor side)	kg/h								
Indoor unit air flow rate	m3/h			512	590			523.2	581.4
Pressure drop in noozles	Pa			208.67	257.62			217.27	249.39
Diameter noozle 1	m			0.07	0.07			0.07	0.07
Diameter noozle 2	m			0.07	0.07			0.07	0.07
Cooling or heating capacity	W			3 514	3 971			3 582	3 930
Power input	W			1 314	1 234			1 297	1 225
EER or COP	W/W			2.67	3.22			2.76	3.21

Sample		3				4			
Method		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode		Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Dry bulb. air inlet. outdoor side	ºC			34.99	6.96			34.96	6.98
Wet bulb. air inlet. outdoor side	ºC			24.03	5.98			24.04	5.96
Dry bulb. air inlet. indoor side	ºC			26.97	19.96			27.04	20.09
Wet bulb. air inlet. indoor side	ºC			19.03	15.00			19.03	15.03
Dry bulb. air outlet. indoor side	ºC			13.45	39.88			13.80	40.20
Wet bulb. air outlet. indoor side	ºC			12.02	21.89			12.59	22.01
Atmospheric pressure	kPa			101.63	101.65			102.03	102.05
Vapour given by the humidifyer (indoor side)	kg/h								
Indoor unit air flow rate	m3/h			516.7	566.2			764.3	828.5
Pressure drop in noozles	Pa			212.08	237.11			466.11	507.91
Diameter noozle 1	m			0.07	0.07			0.07	0.07
Diameter noozle 2	m			0.07	0.07			0.07	0.07
Cooling or heating capacity	W			3 542	3 800			4 831	5 651
Power input	W			1 315	1 236			1 864	1 767
EER or COP	W/W			2.70	3.08			2.59	3.20

II.6.4 Laboratory 4

Sample		1				2			
Method		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode		Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Dry bulb. air inlet. outdoor side	ºC	34.98	6.98			34.98	6.99		
Wet bulb. air inlet. outdoor side	ºC	24.05	6.02			24.04	6.03		
Dry bulb. air inlet. indoor side	ºC	26.98	20.08			27.01	20.04		
Wet bulb. air inlet. indoor side	ºC	18.99	13.97			18.99	13.96		
Dry bulb. air outlet. indoor side	ºC	13.58	40.27			13.46	40.05		
Wet bulb. air outlet. indoor side	ºC								
Atmospheric pressure	kPa	100.101	100.095			100.2	100.1		
Vapour given by the humidifyer (indoor side)	kg/h	1.230				1.240			
Indoor unit air flow rate	m3/h								
Pressure drop in noozles	Pa								
Diameter noozle 1	m								
Diameter noozle 2	m								
Cooling or heating capacity	W	3 585	4 013			3 611	4 048		
Power input	W	1 311	1 208			1 295	1 222		
EER or COP	W/W	2.73	3.32			2.79	3.31		

Sample		3				4			
Method		Calorimeter		Air enthalpy		Calorimeter		Air enthalpy	
Mode		Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating
Dry bulb. air inlet. outdoor side	ºC	34.98	6.92			34.97	7.08		
Wet bulb. air inlet. outdoor side	ºC	24.04	6.01			23.99	6.06		
Dry bulb. air inlet. indoor side	ºC	26.99	20.02			27.01	20.08		
Wet bulb. air inlet. indoor side	ºC	18.99	13.98			18.99	15.03		
Dry bulb. air outlet. indoor side	ºC	13.27	40.34			13.28	37.67		
Wet bulb. air outlet. indoor side	ºC								
Atmospheric pressure	kPa	100.6	100.5			100.6	102.12		
Vapour given by the humidifyer (indoor side)	kg/h	1.270				1.780			
Indoor unit air flow rate	m3/h								
Pressure drop in noozles	Pa								
Diameter noozle 1	m								
Diameter noozle 2	m								
Cooling or heating capacity	W	3 617	4 029			5 139	5 552		
Power input	W	1 311	1 214			1 839	1 718		
EER or COP	W/W	2.76	3.32			2.79	3.23		

II.7 APPENDIX B: RESULTS BY SAMPLE

II.7.1 Sample 1

SAMPLE 1	Results			Differences for each method			Differences for both methods		
COOLING MODE	**Capacity**	**Input**	**EER**	**Capacity**	**Input**	**EER**	**Capacity**	**Input**	**EER**
Lab nº1 calorimeter method	3 626	1 382	2.62	-0.3%	3.3%	-3.6%	0.2%	3.6%	-3.3%
Lab nº2 calorimeter method	3 704	1 321	2.80	1.8%	-1.3%	3.1%	2.4%	-1.0%	3.3%
Lab nº4 calorimeter method	3 585	1 311	2.73	-1.5%	-2.0%	0.5%	-0.9%	-1.7%	0.7%
Average calorimeter method	**3 638**	**1 338**	**2.72**				**0.5%**	**0.3%**	**0.2%**
Lab nº1 air enthalpy method	3 541	1 326	2.67	-1.6%	-0.3%	-1.3%	-2.2%	-0.6%	-1.5%
Lab nº2 air enthalpy method	3 741	1 350	2.77	4.0%	1.5%	2.4%	3.4%	1.2%	2.2%
Lab nº3 air enthalpy method	3 514	1 314	2.67	-2.3%	-1.2%	-1.1%	-2.9%	-1.5%	-1.4%
Average air enthalpy method	**3 599**	**1 330**	**2.70**				**-0.5%**	**-0.3%**	**-0.2%**
Average both methods	**3 618**	**1 334**	**2.71**						

SAMPLE 1	Results				Differences for each method			
COOLING MODE	**Latent**	**Air flow**	**ΔT dry bulb**	**ΔT wet bulb**	**Latent**	**Air flow**	**ΔT dry bulb**	**ΔT wet bulb**
Lab nº1 calorimeter method	876				0.2%			
Lab nº2 calorimeter method	906				3.7%			
Lab nº4 calorimeter method	841		13.40		-3.9%		2.5%	
Average calorimeter method	**874**							
Lab nº1 air enthalpy method	839	585	13.10	6.30	-7.3%	0.0%	0.2%	-1.8%
Lab nº2 air enthalpy method	911	658	12.44	5.90	0.6%	12.5%	-4.8%	-8.1%
Lab nº3 air enthalpy method	966	512	13.67	7.05	6.7%	-12.5%	4.6%	9.9%
Average air enthalpy method	**905**	**585**	**13.07**	**6.42**				
Average both methods	890							

SAMPLE 1	Results			Differences for each method			Differences for both methods		
HEATING MODE	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**
Lab nº2 calorimeter method	3 912	1 249	3.13	-1.3%	1.7%	-2.9%	-0.4%	2.0%	-2.4%
Lab nº4 calorimeter method	4 013	1 208	3.32	1.3%	-1.7%	2.9%	2.2%	-1.4%	3.6%
Average calorimeter method	**3 963**	**1 229**	**3.23**				**0.9%**	**0.3%**	**0.6%**
Lab nº1 air enthalpy method	3 861	1 203	3.21	-1.1%	-1.6%	0.5%	-1.7%	-1.8%	0.1%
Lab nº2 air enthalpy method	3 875	1 230	3.15	-0.7%	0.6%	-1.4%	-1.3%	0.4%	-1.7%
Lab nº3 air enthalpy method	3 971	1 234	3.22	1.8%	1.0%	0.8%	1.1%	0.8%	0.4%
Average air enthalpy method	**3 902**	**1 222**	**3.19**				**-0.6%**	**-0.2%**	**-0.4%**
Average both methods	**3 926**	**1 225**	**3.21**						

SAMPLE 1			Differences	
HEATING MODE	**Air flow**	**ΔT dry bulb**	**Air flow**	**ΔT dry bulb**
Lab nº4 calorimeter method		20.19		10.1%
Lab nº1 air enthalpy method	646	18.50	0.9%	0.9%
Lab nº2 air enthalpy method	685	16.63	7.0%	-9.3%
Lab nº3 air enthalpy method	590	19.89	-7.9%	8.5%
Average air enthalpy method	**640**	**18.34**		

II.7.2 Sample 2

SAMPLE 2	**Results**			**Differences for each method**			**Differences for both methods**		
COOLING MODE	**Capacity**	**Input**	**EER**	**Capacity**	**Input**	**EER**	**Capacity**	**Input**	**EER**
Lab nº2 calorimeter method	3 688	1 312	2.81	1.1%	0.7%	0.4%	1.0%	0.2%	0.7%
Lab nº4 calorimeter method	3 611	1 295	2.79	-1.1%	-0.7%	-0.4%	-1.1%	-1.1%	0.0%
Average calorimeter method	**3 650**	**1 304**	**2.80**				**-0.1%**	**-0.4%**	**0.3%**
Lab nº2 air enthalpy method	3 730	1 331	2.80	2.0%	1.3%	0.7%	2.1%	1.7%	0.3%
Lab nº3 air enthalpy method	3 582	1 297	2.76	-2.0%	-1.3%	-0.7%	-1.9%	-0.9%	-1.0%
Average air enthalpy method	**3 656**	**1 314**	**2.78**				**0.1%**	**0.4%**	**-0.3%**
Average both methods	**3 653**	**1 309**	**2.79**						

SAMPLE 2					**Differences for each method**			
COOLING MODE	**Latent**	**Air flow**	**ΔT dry bulb**	**ΔT wet bulb**	**Latent**	**Air flow**	**ΔT dry bulb**	**ΔT wet bulb**
Lab nº2 calorimeter method	976				7.1%			
Lab nº4 calorimeter method	847		13.55		-7.1%		5.2%	
Average calorimeter method	**912**							
Lab nº2 air enthalpy method	905	654	12.26	5.84	-5.8%	11.1%	-4.8%	-9.0%
Lab nº3 air enthalpy method	1 016	523	13.50	7.00	5.8%	-11.1%	4.8%	9.0%
Average air enthalpy method	**961**	**589**	**12.88**	**6.42**				
Average both methods	936							

SAMPLE 2	**Results**			**Differences for each method**			**Differences for both methods**		
HEATING MODE	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**
Lab nº2 calorimeter method	3 998	1 231	3.25	-0.6%	0.4%	-0.9%	0.5%	1.0%	-0.4%
Lab nº4 calorimeter method	4 048	1 222	3.31	0.6%	-0.4%	0.9%	1.7%	0.2%	1.4%
Average calorimeter method	**4 023**	**1 227**	**3.28**				**1.1%**	**0.6%**	**0.5%**
Lab nº2 air enthalpy method	3 944	1 199	3.29	0.2%	-1.1%	1.3%	-0.9%	-1.7%	0.8%
Lab nº3 air enthalpy method	3 930	1 225	3.21	-0.2%	1.1%	-1.3%	-1.3%	0.5%	-1.7%
Average air enthalpy method	**3 937**	**1 212**	**3.25**				**-1.1%**	**-0.6%**	**-0.5%**
Average both methods	**3 980**	**1 219**	**3.26**						

SAMPLE 2			**Differences**	
HEATING MODE	**Air flow**	**ΔT dry bulb**	**Air flow**	**ΔT dry bulb**
Lab nº4 calorimeter method		20.01		8.6%
Lab nº2 air enthalpy method	694	16.84	8.8%	-8.6%
Lab nº3 air enthalpy method	581	20.02	-8.8%	8.6%
Average air enthalpy method	**638**	**18.43**		

II.7.3 Sample 3

SAMPLE 3	Results			Differences for each method			Differences for both methods		
COOLING MODE	**Capacity**	**Input**	**EER**	**Capacity**	**Input**	**EER**	**Capacity**	**Input**	**EER**
Lab nº1 calorimeter method	3 593	1 335	2.69	-1.3%	1.3%	-2.7%	-0.9%	0.9%	-1.9%
Lab nº2 calorimeter method	3 708	1 306	2.84	1.9%	-0.9%	2.8%	2.2%	-1.3%	3.5%
Lab nº4 calorimeter method	3 617	1 311	2.76	-0.6%	-0.5%	-0.1%	-0.3%	-0.9%	0.6%
Average calorimeter method	**3 639**	**1 317**	**2.76**				**0.3%**	**-0.4%**	**0.7%**
Lab nº1 air enthalpy method	3 574	1 348	2.65	-1.1%	1.5%	-2.7%	-1.5%	1.9%	-3.4%
Lab nº2 air enthalpy method	3 727	1 321	2.82	3.1%	-0.5%	3.6%	2.8%	-0.1%	2.8%
Lab nº3 air enthalpy method	3 542	1 315	2.70	-2.0%	-1.0%	-0.9%	-2.3%	-0.6%	-1.7%
Average air enthalpy method	**3 614**	**1 328**	**2.72**				**-0.3%**	**0.4%**	**-0.7%**
Average both methods	**3 627**	**1 323**	**2.74**						

SAMPLE 3					Differences for each method			
COOLING MODE	**Latent**	**Air flow**	**ΔT dry bulb**	**ΔT wet bulb**	**Latent**	**Air flow**	**ΔT dry bulb**	**ΔT wet bulb**
Lab nº1 calorimeter method	867				-3.1%			
Lab nº2 calorimeter method	949				6.0%			
Lab nº4 calorimeter method	868		13.72		-3.0%		5.3%	
Average calorimeter method	**895**							
Lab nº1 air enthalpy method	893	583	13.10	6.40	-3.8%	-0.6%	0.6%	-0.6%
Lab nº2 air enthalpy method	892	660	12.45	5.90	-3.9%	12.5%	-4.4%	-8.3%
Lab nº3 air enthalpy method	1 000	517	13.52	7.01	7.7%	-11.9%	3.8%	8.9%
Average air enthalpy method	**928**	**587**	**13.02**	**6.44**				
Average both methods	911							

SAMPLE 3	Results			Differences for each method			Differences for both methods		
HEATING MODE	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**
Lab nº2 calorimeter method	3 879	1 209	3.21	-1.9%	-0.2%	-1.7%	0.4%	-0.2%	0.6%
Lab nº4 calorimeter method	4 029	1 214	3.32	1.9%	0.2%	1.7%	4.3%	0.2%	4.0%
Average calorimeter method	**3 954**	**1 212**	**3.27**				**2.3%**	**0.0%**	**2.3%**
Lab nº1 air enthalpy method	3 783	1 216	3.11	-0.6%	0.4%	-1.0%	-2.1%	0.4%	-2.5%
Lab nº2 air enthalpy method	3 829	1 182	3.24	0.7%	-2.4%	3.1%	-0.9%	-2.4%	1.5%
Lab nº3 air enthalpy method	3 800	1 236	3.08	-0.1%	2.0%	-2.1%	-1.7%	2.0%	-3.6%
Average air enthalpy method	**3 804**	**1 211**	**3.14**				**-1.6%**	**0.0%**	**-1.5%**
Average both methods	**3 864**	**1 211**	**3.19**						

SAMPLE 3			Differences	
HEATING MODE	**Air flow**	**ΔT dry bulb**	**Air flow**	**ΔT dry bulb**
Lab nº4 calorimeter method		20.32		12.3%
Lab nº1 air enthalpy method	629	18.60	-0.9%	2.8%
Lab nº2 air enthalpy method	710	15.75	11.8%	-12.9%
Lab nº3 air enthalpy method	566	19.92	-10.8%	10.1%
Average air enthalpy method	**635**	**18.09**		

II.7.4 Sample 4

SAMPLE 4	Results			Differences for each method			Differences for both methods		
COOLING MODE	**Capacity**	**Input**	**EER**	**Capacity**	**Input**	**EER**	**Capacity**	**Input**	**EER**
Lab nº1 calorimeter method	4 892	1 813	2.70	-0.2%	-0.1%	0.0%	0.2%	-0.4%	0.8%
Lab nº2 calorimeter method	4 835	1 781	2.71	-1.4%	-1.8%	0.4%	-0.9%	-2.2%	1.2%
Lab nº4 calorimeter method	5 139	1 839	2.79	4.8%	1.4%	3.3%	5.3%	1.0%	4.1%
Australian laboratory	4 751	1 825	2.60	-3.1%	0.6%	-3.7%	-2.6%	0.2%	-2.9%
Average calorimeter method	**4 904**	**1 815**	**2.70**				**0.5%**	**-0.4%**	**0.8%**
Lab nº1 air enthalpy method	4 849	1 831	2.65	0.0%	0.1%	0.0%	-0.6%	0.6%	-1.1%
Lab nº2 air enthalpy method	4 862	1 794	2.71	0.3%	-2.0%	2.2%	-0.4%	-1.5%	1.2%
Lab nº3 air enthalpy method	4 831	1 864	2.59	-0.3%	1.9%	-2.2%	-1.0%	2.4%	-3.2%
Average air enthalpy method	**4 847**	**1 830**	**2.65**				**-0.7%**	**0.5%**	**-1.0%**
Average both methods	**4 880**	**1 821**	**2.68**						

SAMPLE 4					Differences for each method			
COOLING MODE	**Latent**	**Air flow**	**ΔT dry bulb**	**ΔT wet bulb**	**Latent**	**Air flow**	**ΔT dry bulb**	**ΔT wet bulb**
Lab nº1 calorimeter method	867				-21.4%			
Lab nº2 calorimeter method	1 227				11.2%			
Lab nº4 calorimeter method	1 216		13.73		10.2%		4.1%	
Average calorimeter method	**1 103**							
Lab nº1 air enthalpy method	994	905	12.70	5.60	-15.4%	12.5%	-3.7%	-11.4%
Lab nº2 air enthalpy method	1 347	745	13.61	6.93	14.7%	-7.4%	3.2%	9.6%
Lab nº3 air enthalpy method	1 182	764	13.24	6.44	0.7%	-5.0%	0.4%	1.8%
Average air enthalpy method	**1 174**	**805**	**13.18**	**6.32**				
Average both methods	1 139							

SAMPLE 4	Results			Differences for each method			Differences for both methods		
HEATING MODE	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**
Lab nº2 calorimeter method	5 518	1 769	3.12	-0.5%	0.1%	-0.6%	-0.4%	-0.2%	-0.4%
Lab nº4 calorimeter method	5 552	1 718	3.23	0.1%	-2.8%	2.9%	0.2%	-3.1%	3.1%
Australian laboratory	5 574	1 813	3.07	0.5%	2.6%	-2.2%	0.6%	2.2%	-2.0%
Average calorimeter method	**5 548**	**1 767**	**3.14**				**0.2%**	**-0.4%**	**0.2%**
Lab nº1 air enthalpy method	5 484	1 823	3.06	-0.8%	2.4%	-2.1%	-1.0%	2.8%	-2.3%
Lab nº2 air enthalpy method	5 453	1 749	3.12	-1.4%	-1.7%	-0.2%	-1.5%	-1.4%	-0.4%
Lab nº3 air enthalpy method	5 651	1 767	3.20	2.2%	-0.7%	2.3%	2.0%	-0.3%	2.1%
Average air enthalpy method	**5 529**	**1 780**	**3.13**				**-0.2%**	**0.4%**	**-0.2%**
Average both methods	**5 539**	**1 773**	**3.13**						

SAMPLE 4			Differences	
HEATING MODE	**Air flow**	**ΔT dry bulb**	**Air flow**	**ΔT dry bulb**
Lab nº4 calorimeter method		17.59		-9.7%
Lab nº1 air enthalpy method	942	18.80	11.5%	-3.4%
Lab nº2 air enthalpy method	765	19.50	-9.5%	0.2%
Lab nº3 air enthalpy method	829	20.11	-2.0%	3.3%
Average air enthalpy method	**845**	**19.47**		

II.8 APPENDIX C: RESULTS BY LABORATORY

II.8.1 Laboratory 1

Calorimeter method	**Results**				**Differences for each method**				**Differences for both methods**		
COOLING MODE	**Capacity**	**Input**	**EER**	**Latent**	**Capacity**	**Input**	**EER**	**Latent**	**Capacity**	**Input**	**EER**
Sample 1	3 626	1 382	2.62	876	-0.3%	3.3%	-3.6%	0.2%	0.2%	3.6%	-3.3%
Sample 3	3 593	1 335	2.69	867	-1.3%	1.3%	-2.7%	-3.1%	-0.9%	0.9%	-1.9%
Sample 4	4 892	1 813	2.70	867	-0.2%	-0.1%	0.0%	-21.4%	0.2%	-0.4%	0.8%
Average					**-0.6%**	**1.5%**	**-2.1%**	**-8.1%**	**-0.2%**	**1.4%**	**-1.5%**

Air enthalpy method	**Results**					**Differences for each method**					**Differences for both methods**		
COOLING MODE	**Capacity**	**Input**	**EER**	**Latent**	**Air flow**	**Capacity**	**Input**	**EER**	**Latent**	**Air flow**	**Capacity**	**Input**	**EER**
Sample 1	3 541	1 326	2.67	839	585	-1.6%	-0.3%	-1.3%	-7.3%	0.0%	-2.2%	-0.6%	-1.5%
Sample 3	3 574	1 348	2.65	893	583	-1.1%	1.5%	-2.7%	-3.8%	-0.6%	-1.5%	1.9%	-3.4%
Sample 4	4 849	1 831	2.65	994	905	0.0%	0.1%	0.0%	-15.4%	12.5%	-0.6%	0.6%	-1.1%
Average						**-0.9%**	**0.4%**	**-1.3%**	**-8.8%**	**4.0%**	**-1.4%**	**0.6%**	**-2.0%**

Air enthalpy method	**Results**				**Differences for each method**				**Differences for both methods**		
HEATING MODE	**Capacity**	**Input**	**COP**	**Air flow**	**Capacity**	**Input**	**COP**	**Air flow**	**Capacity**	**Input**	**COP**
Sample 1	3 861	1 203	3.21	646	-1.1%	-1.6%	0.5%	0.9%	-1.7%	-1.8%	0.1%
Sample 3	3 783	1 216	3.11	629	-0.6%	0.4%	-1.0%	-0.9%	-2.1%	0.4%	-2.5%
Sample 4	5 484	1 823	3.06	942	-0.8%	2.4%	-2.1%	11.5%	-1.0%	2.8%	-2.3%
Average					**-0.8%**	**0.4%**	**-0.9%**	**3.8%**	**-1.6%**	**0.5%**	**-1.6%**

II.8.2 Laboratory 2

Calorimeter method	Results				Differences for each method				Differences for both methods		
COOLING MODE	**Capacity**	**Input**	**EER**	**Latent**	**Capacity**	**Input**	**EER**	**Latent**	**Capacity**	**Input**	**EER**
Sample 1	3 704	1 321	2.80	906	1.8%	-1.3%	3.1%	3.7%	2.4%	-1.0%	3.3%
Sample 2	3 688	1 312	2.81	976	1.1%	0.7%	0.4%	7.1%	1.0%	0.2%	0.7%
Sample 3	3 708	1 306	2.84	949	1.9%	-0.9%	2.8%	6.0%	2.2%	-1.3%	3.5%
Sample 4	4 835	1 781	2.71	1 227	-1.4%	-1.8%	0.4%	11.2%	-0.9%	-2.2%	1.2%
Average					**0.8%**	**-0.8%**	**1.6%**	**7.0%**	**1.2%**	**-1.0%**	**2.2%**

Air enthalpy method	Results					Differences for each method					Differences for both methods		
COOLING MODE	**Capacity**	**Input**	**EER**	**Latent**	**Air flow**	**Capacity**	**Input**	**EER**	**Latent**	**Air flow**	**Capacity**	**Input**	**EER**
Sample 1	3 741	1 350	2.77	911	658	4.0%	1.5%	2.4%	0.6%	12.5%	3.4%	1.2%	2.2%
Sample 2	3 730	1 331	2.80	905	654	2.0%	1.3%	0.7%	-5.8%	11.1%	2.1%	1.7%	0.3%
Sample 3	3 727	1 321	2.82	892	660	3.1%	-0.5%	3.6%	-3.9%	12.5%	2.8%	-0.1%	2.8%
Sample 4	4 862	1 794	2.71	1 347	745	0.3%	-2.0%	2.2%	14.7%	-7.4%	-0.4%	-1.5%	1.2%
Average						**2.4%**	**0.1%**	**2.2%**	**1.4%**	**7.2%**	**2.0%**	**0.3%**	**1.6%**

Calorimeter method	Results			Differences for each method			Differences for both methods		
HEATING MODE	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**
Sample 1	3 912	1 249	3.13	-1.3%	1.7%	-2.9%	-0.4%	2.0%	-2.4%
Sample 2	3 998	1 231	3.25	-0.6%	0.4%	-0.9%	0.5%	1.0%	-0.4%
Sample 3	3 879	1 209	3.21	-1.9%	-0.2%	-1.7%	0.4%	-0.2%	0.6%
Sample 4	5 518	1 769	3.12	-0.5%	0.1%	-0.6%	-0.4%	-0.2%	-0.4%
Average				**-1.1%**	**0.5%**	**-1.5%**	**0.0%**	**0.6%**	**-0.7%**

Air enthalpy method	Results				Differences for each method				Differences for both methods		
HEATING MODE	**Capacity**	**Input**	**COP**	**Air flow**	**Capacity**	**Input**	**COP**	**Air flow**	**Capacity**	**Input**	**COP**
Sample 1	3 875	1 230	3.15	685	-0.7%	0.6%	-1.4%	7.0%	-1.3%	0.4%	-1.7%
Sample 2	3 944	1 199	3.29	694	0.2%	-1.1%	1.3%	8.8%	-0.9%	-1.7%	0.8%
Sample 3	3 829	1 182	3.24	710	0.7%	-2.4%	3.1%	11.8%	-0.9%	-2.4%	1.5%
Sample 4	5 453	1 749	3.12	765	-1.4%	-1.7%	-0.2%	-9.5%	-1.5%	-1.4%	-0.4%
Average					**-0.3%**	**-1.1%**	**0.7%**	**4.5%**	**-1.2%**	**-1.3%**	**0.0%**

II.8.3 Laboratory 3

Air enthalpy method	Results					Differences for each method					Differences for both methods		
COOLING MODE	**Capacity**	**Input**	**EER**	**Latent**	**Air flow**	**Capacity**	**Input**	**EER**	**Latent**	**Air flow**	**Capacity**	**Input**	**EER**
Sample 1	3 514	1 314	2.67	966	512	-2.3%	-1.2%	-1.1%	6.7%	-12.5%	-2.9%	-1.5%	-1.4%
Sample 2	3 582	1 297	2.76	1 016	523	-2.0%	-1.3%	-0.7%	5.8%	-11.1%	-1.9%	-0.9%	-1.0%
Sample 3	3 542	1 315	2.70	1 000	517	-2.0%	-1.0%	-0.9%	7.7%	-11.9%	-2.3%	-0.6%	-1.7%
Sample 4	4 831	1 864	2.59	1 182	764	-0.3%	1.9%	-2.2%	0.7%	-5.0%	-1.0%	2.4%	-3.2%
Average						**-1.7%**	**-0.4%**	**-1.2%**	**5.2%**	**-10.1%**	**-2.0%**	**-0.2%**	**-1.8%**

Air enthalpy method	Results				Differences for each method				Differences for both methods		
HEATING MODE	**Capacity**	**Input**	**COP**	**Air flow**	**Capacity**	**Input**	**COP**	**Air flow**	**Capacity**	**Input**	**COP**
Sample 1	3 971	1 234	3.22	590	1.8%	1.0%	0.8%	-7.9%	1.1%	0.8%	0.4%
Sample 2	3 930	1 225	3.21	581	-0.2%	1.1%	-1.3%	-8.8%	-1.3%	0.5%	-1.7%
Sample 3	3 800	1 236	3.08	566	-0.1%	2.0%	-2.1%	-10.8%	-1.7%	2.0%	-3.6%
Sample 4	5 651	1 767	3.20	829	2.2%	-0.7%	2.3%	-2.0%	2.0%	-0.3%	2.1%
Average					**0.9%**	**0.8%**	**-0.1%**	**-7.4%**	**0.1%**	**0.7%**	**-0.7%**

II.8.4 Laboratory 4

Calorimeter method	Results				Differences for each method				Differences for both methods		
COOLING MODE	**Capacity**	**Input**	**EER**	**Latent**	**Capacity**	**Input**	**EER**	**Latent**	**Capacity**	**Input**	**EER**
Sample 1	3 585	1 311	2.73	841	-1.5%	-2.0%	0.5%	-3.9%	-0.9%	-1.7%	0.7%
Sample 2	3 611	1 295	2.79	847	-1.1%	-0.7%	-0.4%	-7.1%	-1.1%	-1.1%	0.0%
Sample 3	3 617	1 311	2.76	868	-0.6%	-0.5%	-0.1%	-3.0%	-0.3%	-0.9%	0.6%
Sample 4	5 139	1 839	2.79	1 216	4.8%	1.4%	3.3%	10.2%	5.3%	1.0%	4.1%
Average					**0.4%**	**-0.4%**	**0.8%**	**-0.9%**	**0.7%**	**-0.7%**	**1.4%**

Calorimeter method	Results			Differences for each method			Differences for both methods		
HEATING MODE	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**	**Capacity**	**Input**	**COP**
Sample 1	4 013	1 208	3.32	1.3%	-1.7%	2.9%	2.2%	-1.4%	3.6%
Sample 2	4 048	1 222	3.31	0.6%	-0.4%	0.9%	1.7%	0.2%	1.4%
Sample 3	4 029	1 214	3.32	1.9%	0.2%	1.7%	4.3%	0.2%	4.0%
Sample 4	5 552	1 718	3.23	0.1%	-2.8%	2.9%	0.2%	-3.1%	3.1%
Average				**1.0%**	**-1.1%**	**2.1%**	**2.1%**	**-1.0%**	**3.0%**