

REFRIGERANT SELECTION IN ROOM AIR CONDITIONING INDUSTRY FOR
SUSTAINABLE DEVELOPMENT

A Thesis

by

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ABSTRACT

History shows us that refrigerant choice was never easy, with an evolution from natural refrigerants to synthesized refrigerants, and maybe back to natural ones.

Pursuing alternative substance or technology with zero ozone depleting potential (ODP) once was the priority concern of governments and manufacturers and was regarded as a long-term solution and the best way to protect the environment since the Montreal Protocol has been enforced to phase out all ozone depleting refrigerants that have been commonly used in air-conditioning. While the consequence of Climate Change issue is better known today, this argument will be challenged because of future sustainability concerns, and to be more precisely, refrigerant selections anticipate the need to mitigate greenhouse effect as well.

Manufacturers have commercialized more than 50 new refrigerants (including blends) in the last decade, and they are examining additional candidates. There is no general rule governing the selection of refrigerants. But basically refrigerants are examined according to some classic criteria in thermodynamic properties, technological and economic aspects and safety and environmental factors. Many relevant research and programs are conducted and most of them concentrate on one indicator such as energy efficiency or flammability of refrigerants, or in a given appliance under some specific standards, without careful consideration of regional differences such as local climatic conditions, local regulations and standards and “cultural” criteria associated with professions, applications, customs and user training levels. Unfortunately no current

refrigerants are ideal. Furthermore, future discovery of ideal refrigerant is extremely unlikely. Thus, from the perspective of different countries, how to make an informed choice from the existing imperfect candidates remains a tough challenge.

In this paper, methodologies were demonstrated to evaluate some typical refrigerants based on their performance in safety issues, environmental protection, and economic efficiency, with thermodynamic property and technology innovation incorporated from a whole country's perspective. Aiming at providing suggestions and recommendations to the national room air conditioning industry associations and also international manufacturers, the differences of local climatic conditions, technical gap, customer's use habit and environmental awareness among countries and regions are taken into consideration. Meanwhile case study of China and Japan utilizing this methodology are analyzed and compared. Additionally weighting methodology and its distance-to-target principle were also introduced briefly, as well as their important application in refrigerant selection.

The results of the research showed:

- In safety aspect, specific hazards from refrigerant always fall into two categories: toxicity and flammability, and their corresponding indicators TLV-TWA and HOC were chosen. Based on classification standard involving these indicators, the refrigerants currently being widely used in air conditioning industry are all categorized into group A1, with the properties of non-flammability and low toxicity, except R717. The HC alternatives, particularly R290, which attract the attention of air conditioning and

refrigeration industry recently, are proven to have higher flammability and accidents occurred due to their high flammability. China and Japan have showed different acceptance on the flammable refrigerants which may lead to the different refrigerant selection in the future. On one side China believes the bright future of R290 and its risk management, while on the other hand Japan's lowest requirement in flammability is A/B2L. Further risk assessment is needed if flammable refrigerants are utilized in the processed of production, transportation, operation, after sales service and disposal. Moreover special training is suggested to be provided to the services suppliers and corresponding requirements are recommended to deliver the after sales services of air conditioners.

- In Environmental protection aspect, Ozone depletion and global warming are the main impacts caused by refrigerants. Consequently ODP and TEWI are carefully examined and then integrated into a whole environmental indicator by utilizing weighting methodology. TEWIs in average for a whole country when using different refrigerants vary a lot. In different cases, based on many factors such as total ownership of RAC, level of technology, energy structure, use habit and local climate conditions, the best or worst performers may change. In general, Japan has a smaller TEWI value when using the same refrigerant in the similar air conditioning system, mainly due to the technical gap and favorable local climatic conditions and energy structure. In terms of Environmental indicator, there exist great differences among

countries for the same refrigerant. Despite the higher absolute value of TEWI and ODS emission by a Chinese room air conditioning system, the relative value of environmental impact to a whole country that it causes is still limited due to its much larger territory area and huger population than Japan. This difference may affect the sensitivity of the national industry to environmental sector and may even lead to the final different choice in refrigerants. Basically the second generation refrigerants have a much higher value for Environmental indicators than others due to high ODP while the natural refrigerants perform well in ozone depletion impact, but differ in global warming impact due to efficiency differences.

- In economic efficiency aspect, price is the first concern. Basically the more complicated the chemical structure of refrigerant is, the more expensive it is. The availability also influences the selection process. Consequently the natural refrigerants keep a favorable position other than those synthesized refrigerants in HFCs. HFO1234yf has a much higher cost, including refrigerant price, production cost, handling cost and patent fees than the ones being used. Additional cost is required for flammable refrigerants when taking safety measures in application and handling.

Keywords: Refrigerant Selection, Safety Issues, Environmental Protection, Economic Efficiency, Local Climatic Conditions, TEWI, Environmental Indicator, Weighting Methodology.