UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF SMALL PORTABLE AIR CONDITIONER BY PELTIER MODULE

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Refrigeration and Air Conditioning System) (Hons).

by

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

DEVELOPMENT OF SMALL PORTABLE AIR CONDITIONER BY PELTIER MODULE

SESI PENGAJIAN: **2017/18 Semester 1**

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I hereby, declared this report entitled “Development of small portable air conditioner by peltier module” is the results of my own research except as cited in references.

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Engineering Technology (Refrigeration and Air-Conditioning System) with Honours. The member of the supervisory is as follow:

……

(MR. MOHD FARID BIN ISMAIL)

ABSTRACT

The tropical climate country, especially in Malaysia is classify by high temperature and relative humidity and this phenomenon resist the thermal comfort of human in building. Commonly, small personal office room has low cooling load compare to other place with heavy work activities. High power consumption and initiate cost for compressor-based unit used in small room is a big waste instead of using small portable air-conditioning. The small personal air-conditioning system by using Peltier effect module is subjected to control the comfort level by removing the sensible and latent heat inside the space. Peltier is thermoelectric semiconductor that provide cool and hot plate after electric is supply to the plate. The cool side use to reduce temperature and the hot side is remove in the system. This project's able to reduce the power consumption, cost and provide thermal comfort zone in a dedicated area. The benefit of this project is able to cut the cost by reducing the power consumption and also green technology device because of not using refrigerant that can harm the world.

ABSTRAK

Negara iklim tropika, terutamanya di Malaysia adalah dikelaskan oleh suhu tinggi dan kelembapan relatif dan fenomena ini menentang keselesaan haba manusia dalam bangunan. Umumnya, bilik pejabat peribadi kecil mempunyai beban pendinginan yang rendah berbanding dengan tempat lain dengan aktiviti kerja berat. Penggunaan kuasa tinggi dan memulakan kos untuk unit berasaskan pemampat yang digunakan di dalam bilik kecil adalah sisa besar dan bukannya menggunakan penghawa dingin mudah alih kecil. Sistem penghawa dingin peribadi kecil dengan menggunakan modul kesan Peltier tertakluk untuk mengawal tahap keselesaan dengan mengeluarkan haba yang masuk akal dan terpendam di dalam ruang. Peltier adalah semikonduktor termoelektrik yang menyediakan plat sejuk dan panas selepas bekalan elektrik ke plat. Penggunaan sisi sejuk untuk mengurangkan suhu dan bahagian panas dikeluarkan dalam sistem. Projek ini dapat mengurangkan penggunaan kuasa, kos dan menyediakan zon selesa terma di kawasan khusus. Manfaat projek ini dapat mengurangkan kos dengan mengurangkan penggunaan kuasa dan juga peranti teknologi hijau kerana tidak menggunakan bahan pendingin yang dapat membahayakan dunia.

DEDICATION

To my beloved parents, I acknowledge my sincere obligation and appreciation to them for their love, vision and sacrifice throughout my life. I am humble my thankful for their sacrifice, tolerance and considerate that were inevitable to make this effort thinkable. Their sacrifice had inspired me from the day I learned how to read, write, and think until what I have become now. I disable to bargain the appropriate words that could properly describe my appreciation for their devotion, support and faith in my ability to reach my dreams. Lastly, I would like to lead my gratitude to any person that contributes to my final year project either it is directly or indirectly. I would like to acknowledge their comments and suggestions, which are crucial for the successful completion of this research.

ACKNOWLEDGEMENT

First of all, all praise to Allah the Almighty for giving me the strength, health and patience to complete this project. I would like to express my gratitude to my supervisor Mr Mohad Farid Bin Ismail for his supervision and guidance that have guided me in accomplishing this project. I have to thank my parents for their unstop support througout entire life. Besides that, I am grateful for having my housemates and beloved friend as my companion along the way while working on this project. Finally, thanks a lot to everyone that directly and indirectly involved in helping me to finish this project succesfully. Thank you so much.

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INTRODUCTION

1.0 Background study

Thermal comfort zone is important for human race to get a better lifestyle and provide sensation of physical and mental. According to Nicol's comfort formula, the neutral air temperature needs to be maintained at 26.2°C (Humphreys, et al. 2001). In order to provide thermal comfort zone, hot temperature must be remove from the space. A private office that have an occupant with light activities contain low cooling load. Then, it requires less cooling energy that generate by the equipment to remove the load within the space. Compressor-based HVAC unit is a conventional unit use in a worldwide to control the temperature and humidity. The compressor-based unit is consumed energy to condition the air by basic refrigeration cycle where the heat in space is absorbed and removed to surrounding. Unfortunately, this conventional unit containing several problems in order to provide a comfort zone for the occupant. This unit consume lot of power to run the system and also provide an extra cooling effect. By this statement, it shows that there is wastage occur by using this conventional unit. Next, this conventional unit also use the refrigerant as a medium to transport heat and energy. The usage of refrigerant is absolutely not economic to the environmental. Hence, this project is lead to counter these two main problem on the conventional unit.

1.1 Problem statement

Split unit or others conventional unit are the famous equipment to provide thermal comfort in dedicated area which is private office. The thermal comfort zone that standardized by the (ASHRAE,2014) is around 22°C – 24°C for most of building in Malaysia. The cooling load inside the private office is quite low but the cooling effect provided by the conventional unit is too extra. The cooling load of the private office is small due to low working activities and less electrical appliances. Hence, the usage of compressor-based unit is not suitable for personal office or other place that has low cooling load because of the unit is consumed high power for conditioning process. This statement referring that there is wastage occur during the cooling process inside the building as the cooling load is not tally with the cooling effect. Hence, it may consume a lot of power during the running system. Next, the unit also high installation and maintenance cost due to complex system. The usage of refrigerant in compressor-based unit is harm the environment where the properties contain in refrigerant will lead to ozone depletion and global warming. The suitable system for private office is small portable air conditioner. The non-mechanical component of the system will reduce maintenance cost and energy consumption due to less work needed to operate the unit. The small portable air-conditioning use low amount of electrical energy to run the whole system.

1.2 Aims and objectives

This project aim is to develop a portable air conditioning system by applying Peltier module that provide thermal comfort in dedicated area. The system is expected to reduce power consumption, reduce the maintenance and installation cost. There are several objectives to achieve the aims;

1. To design a few concepts of small portable Peltier air-conditioner and to select the best design.
2. To fabricate the portable air-conditioning system according to selected design.
3. To test the product performance

1.3 Work scope

There are several unavoidable limitations in this project. First, small size of the product is limited for personal use due to the range of conditioning area is 1.5 meter from the device. Second, the selected area for this research is a small office for a person or restricted area that has light activity and limited equipment such as personal computer and lighting Third, the product is only control the temperature by regulating heating and cooling within temperature range between 23°C to 26°C which is thermal comfort zone temperature.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter will discuss about the relevance of this project with others research to provide a better research and avoid unnecessary repetition of problem area on this study. The portable air-conditioner is a device that provide the thermal comfort zone and less power consumption used. The temperature can be control by using thermoelectric plate (Peltier) effect by supply electrical energy to the plate.

2.1 Tropical and humid climate

Country that lie on the equatorial are faced hot and humid climate throughout a year and there is no summer and winter. This phenomenon occur because of sun is overhead at the equator, it is expose to solar radiation. Malaysia is one of the country at south-east Asia that undergoes this phenomenon. Generally, Malaysia was divided by two regions which is peninsula and Borneo. These two regions have slight different hot climate because of different value of solar radiation in each region. Variation in frequency and intensity of incident solar radiation may produce a different regional (Haigh, 2011). The tropical climate is lead to the huge amount of load inside a building.

2.2 Cooling load

Cooling load is energy must be removed from a space to maintain the temperature & humidity at the design values. When thermal loads push conditions outsider of the comfort range, HVAC systems are used to bring the thermal conditions back to the comfort conditions. There are several categories of load component which is external load, internal load and others load.

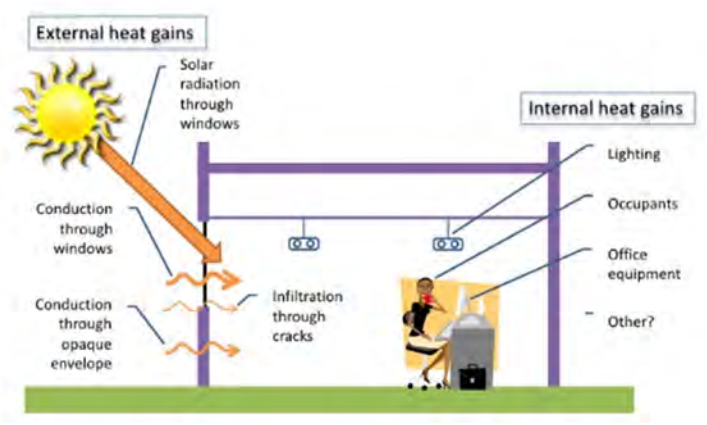

Figure 1: source of cooling load

External load is originated from outside heat source or unconditioned space from other space such as heat gain through wall and roof, solar heat gains from windows, conductive heat gain through fenestration and partition and infiltration of outdoor air. From a study in Hong Kong, solar heat gain via fenestration was dominated heat through inside building Solar which is 40% - 50% heat gain is come from solar radiation flow through fenestration. (Li & Lam, 2000).

Internal load is originated within space itself such as heat gain from people activities, electric light, equipment and appliances. Occupancy is effected the power of consumption in chiller system where University of Hong Kong was measure the power consumption by change the number of occupancy. The power at chiller is increased by increasing the occupancy.(Kwok, Yuen, & Lee, 2011).

Other sources of load occur from heat gains or losses associated with moving cool fluids to and from the conditioned space. Most of the load is from the losses of energy such as friction loss in the ducting, heat loss at the blower due to encounter the air friction and others. This load is minor value in the cooling load.

2.2.1 Cooling load calculation

Cooling load can be calculated by many type of method such as rule of thumb, cooling load temperature different (CLTD) and software. The calculation of cooling load was important to select the suitable system that should be installed to remove the load efficiently. The building cooling loads computed by simulation based on local weather data can form a good basis for plant sizing (Li, Wong, & Lam, 2003). Rule of thumb is the easiest way to find cooling load but not accurate as other method. Hence, rule of thumb is use in common to predict the cooling load of space. The calculation is only need area of selected space to calculate the cooling load.

Applications	Occupancy Sq Ft / Person			Lighting Watts / Sq Ft			Fresh CFM / Person			Air CFM / Sq Ft			Room Sensible Btuh / Sq Ft			Room Total Btuh / Sq Ft			Grand Total Btuh / Sq Ft			Refrigeration Sq Ft / Ton*			Supply Air CFM / Sq Ft		
	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi	Lo	Avg	Hi
Apartments (Flats)	150	100	50	1.0	2.0	4.0	25	35	40	.25	.35	.50	15	25	45	20	30	50	30	40	60	400	300	200	.75	1.25	1.75
Auditoriums, Theaters	15	10	5	1.0	2.0	3.0	5.0	15	30	.50	1.5	2.5	25	35	50	45	55	70	60	80	120	200	150	100	1.25	1.5	2.5
Educational Facilities																											
Classrooms	30	25	20	2.0	4.0	6.0	5.0	7.5	10	.20	.30	.40	25	40	55	35	50	65	45	60	80	275	200	150	1.0	1.4	1.8
Laboratories	75	60	40	2.0	3.0	6.0	10	15	20	.20	.40	.60	30	40	55	35	45	65	45	60	75	275	200	160	1.0	1.4	1.8
Cafeteria-Coffee House	20	15	10	1.5	3.0	4.5	7.5	10	15	.40	.60	.80	25	45	65	35	60	75	55	80	110	225	150	110	1.0	1.5	2.1
Factories	50	35	25	3.0	4.5	6.0	5.0	10	15	.10	.25	.50	20	45	75	30	60	85	50	80	130	240	150	90	1.0	2.25	3.0
Public Areas	200	150	100	9.0‡	10.0‡	12.0‡	5.0	10	15	.05	.10	.15	35	55	75	40	60	80	60	80	120	200	150	100	1.5	2.75	3.0
Light Manufacturing	300	250	200	15.0‡	45.0‡	60.0‡	5.0	10	15	.03	.08	.10	75	115	155	80	120	160	120	150	200	100	80	60	3.0	4.0	6.5
Heavy Manufacturing**	20	15	10	1.0	1.5	2.0	5.0	10	15	.50	.75	1.0	30	35	50	40	50	70	60	85	120	200	150	100	1.0	1.1	1.4
Hospitals																											
Patient Rooms†	100	60	40	1.0	2.0	3.0	75	90	100	.75	1.5	2.5	15	35	50	20	40	55	80	120	165	200	100	75	.75	1.2	1.7
Public Areas	130	100	65	2.0	3.0	4.0	10	20	30	.25	.75	1.5	10	15	35	15	20	40	30	45	100	400	275	120	.75	1.2	1.7
Laboratories	150	100	50	2.0	5.0	10.0	20	30	50	.20	.50	1.0	25	45	60	30	55	70	45	70	100	275	175	120	1.0	1.5	2.0
Libraries	150	100	50	2.0	4.0	6.0	5.0	7.5	10	.10	.20	.30	20	30	50	25	35	55	30	45	70	400	275	175	1.0	1.1	1.7
Doctors Clinics	150	100	50	2.0	4.0	6.0	20	25	30	.25	.40	.60	20	40	60	25	45	65	40	60	80	300	200	150	1.0	1.4	2.0
Offices																											
Private	150	125	100	4.0	6.0	8.0	20	25	30	.25	.40	.60	25	50	75	30	55	80	40	75	90	300	175	135	1.0	1.7	2.4
General-Perimeter	125	100	75	4.0	6.0	8.0	10	15	20	.15	.25	.40	20	35	70	25	40	75	30	50	85	400	250	150	1.0	1.2	2.3
General-Interior	125	100	75	4.0	6.0	8.0	10	15	20	.15	.25	.40	15	20	30	20	25	35	25	30	40	475	400	300	.75	1.0	1.1
Conference Rooms	45	30	15	4.0	6.0	8.0	20	30	50	.40	1.0	1.5	30	55	80	40	65	90	60	85	120	200	150	100	1.0	1.8	2.7
Restaurants	25	20	15	1.5	1.7	2.0	10	15	20	.50	.75	1.0	30	35	50	40	50	70	60	85	120	200	150	100	1.25	1.5	2.0
Shopping Centers																											
Beauty & Barber Shops	45	40	25	3.0‡	5.0‡	9.0‡	7.5	15	20	.20	.50	1.0	25	35	55	30	40	60	50	60	80	250	200	150	1.25	1.5	2.0
Department Stores -Basement	40	30	20	3.0	4.0	5.0	5.0	7.5	10	.10	.20	.25	20	30	45	25	35	50	35	45	60	325	275	200	1.0	1.4	1.75
-Main Floor	40	25	20	4.0	5.0‡	9.0‡	5.0	7.5	10	.15	.25	.35	25	35	45	30	40	50	40	50	60	300	250	200	1.0	1.5	2.0
-Upper Floors	80	50	40	2.0	4.0	6.0‡	5.0	5.0	7.5	.05	.10	.15	15	25	35	20	30	40	30	40	50	400	300	250	.80	1.0	1.2
	40	30	25	2.0	3.0	4.0	10	15	20	.25	.35	.50	30	35	45	40	45	55	60	65	75	200	180	160	1.25	1.5	2.0
	40	25	20	3.0	4.0	6.0	5.0	7.5	10	.15	.25	.35	25	35	45	30	40	50	40	50	60	300	250	200	1.0	1.4	2.0
	60	40	30	1.0	1.5	2.0	5.0	7.5	10	.10	.20	.30	10	15	25	15	20	30	25	30	40	500	400	300	.75	1.2	1.5
Specialty Shops	60	50	40	2.0	3.0	4.0	5.0	7.5	10	.10	.20	.30	25	35	45	30	40	50	40	50	60	300	250	200	1.2	1.4	2.0

Figure 2: Design and cooling load check figure (ASHRAE,2014)

2.2.2 Office cooling load

Private office cooling load is not much as factory and bigger space because of the area and volume of space is affected the cooling load. The bigger the space the bigger the area that expose to the sunlight and higher chances of external load to entering the space. Based on the rule of thumb table, private office occupancy is 150 ft^2/person, lighting watt is 4 watt/ft^2 and room sensible is 25 btuh/ft^2. By this data, cooling load of office room can be determined depend on the size of office. Office cooling load is small then require small system to remove the sensible and latent heat inside the office which is 3000 btu/hr to 5000 btu/hr (SAHU, n.d.). Simulation of cooling load was run and office building contain 4267 btu/hr and require 0.6 Hp equipment to remove the load.(Lam & Li, 1999).

2.3 Thermal comfort

Human thermal comfort is the state of mind that expresses satisfaction with the surrounding environment. Thermal comfort is affected by body heat conduction, convection, type of clothes and rate metabolism of human. The state of thermal comfort of a person has a close relationship with physical and mental of themselves. Each person has different satisfaction on requirement of thermal comfort.

Criteria for acceptable thermal comfort are specified as requirement for general thermal comfort. Prediction for thermal comfort will be measure through PMV-PPD method. If the value of PMV is zero which is natural condition, it will correspond to 5%of people dissatisfied with the environment. If the PMV value is within range between -0.5 to 0.5, the level of people dissatisfaction is approximately to 10% (ASHRAE, 2009).

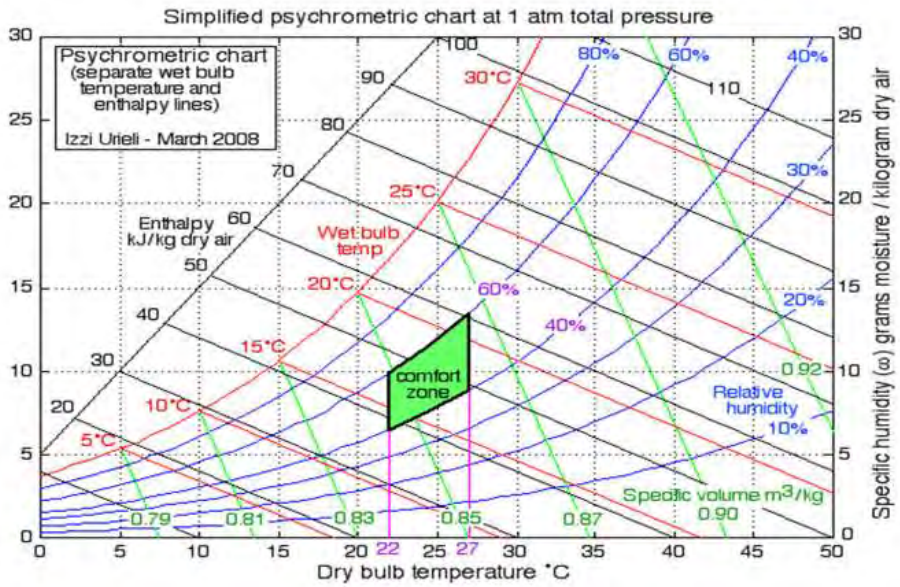

Figure 3: Psychometric chart of comfort zone (ASHRAE,2014)

Parameter	Acceptable range in 8-TWA
Temperature (°C)	23-26
Relative humidity (%)	40-70
Air velocity (m/s)	0.15-0.5

*TWA= time-weighted average for up to 8hours/day

2.4 Air conditioning is used to provide thermal comfort zone

Air-conditioning is a treatment of air as simultaneously control its temperature, moisture content, quality and circulation as required by occupants, a process or products in the space. Air-conditioner is a device that remove the heat from one space in order to provide thermal comfort zone. The low temperature cannot go to the hot region except with help equipment which is refrigeration equipment. By second law of thermodynamic, the energy must be add to the system to change the natural phenomenon.(Rosen, 1999) Most of air-conditioning is use refrigerant to complete a refrigeration cycle. There are four main component of refrigeration cycle which is compressor, condenser, expansion valve and evaporator.

2.4.1 Basic cycle of refrigeration

The basic cycle of refrigeration is compressor will compress the gas phase of refrigerant. At this compression, the gas refrigerant will increase the temperature and pressure to the next component which is condenser. Condenser is a heat remover; the compressed gas will go through condenser and drop the temperature but the pressure is remained same. The gas refrigerant will turn into liquid refrigerant after through the condenser as the condensation process occurred.

Liquid phase of refrigerant will through an expansion valve, the temperature and pressure will drop at this point and straight to the evaporator. Evaporator is a heat absorber; the liquid phase of refrigerant through an evaporator, evaporation process occurred will change the liquid to gas phase and the temperature will slightly increase.(Wang, 2000).

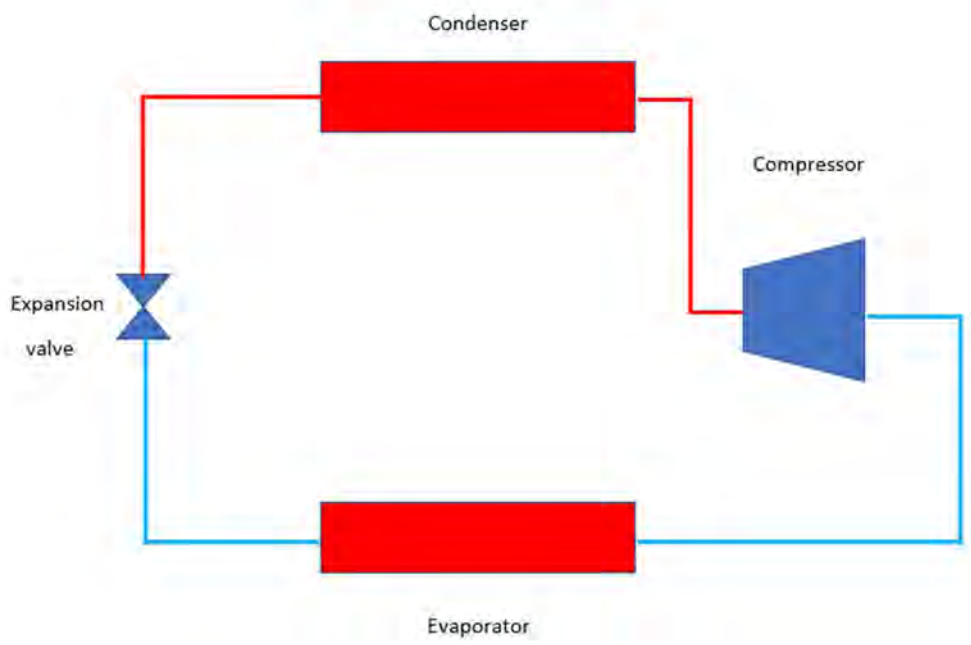

Figure 4: basic cycle of refrigeration cycle

2.4.2 Conventional unit use in office

There are possibilities of equipment that use to remove cooling load of office which mean a small amount of cooling load space. Most of air-conditioners used is low power consume such as split unit and portable air-conditioner as the sensible and latent heat contained in office is low. Commonly, the type of air-conditioner is an individual system which is self-contained in one packaged and factory-made air conditioner to serve one or two rooms. It uses vapour compression cycle directly to cool the indoor air for small loads. The comparison of these type air conditioner used from one brand which is Daikin. The specification of both air conditioner is the lowest cooling capacity type in one catalogue.

2.5 Split unit

Split unit is the popular equipment for cooling purpose because of high efficiency. The ductless split system can cool for multiple zone. It is not requiring ducting like central system. the split unit have two section which is outdoor and indoor. Outdoor unit consist of condenser, expansion valve and compressor but indoor unit only consist of evaporator. All the data of the specification will be discussing is from Daikin Catalogue. (Daikin, 2015)

Figure 5: Daikin split unit (DAIKIN, 2015)