HANDHELD GAS LEAKAGE DETECTOR

by

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Dissertation submitted in partial fulfilment of
the requirements for the
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CERTIFICATION OF APPROVAL

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Electrical & Electronics Engineering Programme
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in partial fulfilment of the requirement for the
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Approved by,

(Assoc Prof Josefina Barnachea Janier)
Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
May 2011

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(NORADAWIYAH BINTI HASHIM)

ABSTRACT

Gas leakage is a very common case that happens almost everyday in our lives. Gas detection is an important element for protection plan for human life and property. This project is focused in the construction of handheld device to detect the presence of gas leakage, which in this case, the Liquefied Petroleum Gas (LPG). It is a sensor based gas leakage detector and it made used of the semiconductor type of gas sensor. The detector indicates gas leakage by changing the value on LCD when it detects the presence of gas. This project exposes the knowledge of LPG and gas sensor application besides introducing an easy and user friendly gas leakage detector.

ACKNOWLEDGEMENTS

All praised to Allah, Lord of the world, whom, through His mercy and grace, has revealed some of His knowledge to the author in finishing this project.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Gas leakage detector is a device to detect any gas leakage and alert the user about the leakage. Industrial products consist of combustible and hazardous elements such as Propane (C3), Butane (C4) and Liquefied Petroleum Gas (LPG), thus the gas leakage detector is a very crucial device in order to detect the presence of gas leakage. This project is focusing on building a handheld prototype to detect gas leakage using a semiconductor type of gas sensor.

1.2 Problem Statement

Nowadays, gas leakage occurs almost every day, be it at home or workplace. Thus, an early-warning device is needed to reduce the risk to personnel and plant by providing more time to take protective or remedial action. The challenge of this project is to design prototype of a gas leakage detector that can detect and respond automatically whenever gas leakage occurs.

One of the accidents involving LPG gas leakage occurred in Noida, India, where 50 workers were affected by the leakage [1].

"Noida, Nov 17 (IANS) Over 50 employees of leading multinational Samsung's washing machine assembly plant here were taken to hospital after being affected by a gas leakage in the plant Tuesday evening, officials said. The employees were taken to the local Kailash Hospital where the condition of six of them was stated to be serious.

Superintendent of Police (City) Ashok Kumar Tripathi said: "Our first priority was to provide immediate treatment to the victims. They all are out of danger now. From the initial inspection, it seems that the gas was probably LPG that got leaked from a pipeline in the lift installed in plant. But, we are inquiring more into it and trying to find the exact point of leakage."

This incident shows that a device to detect the gas leakage is crucially needed to alert everyone about the leakage and prevent serious injury.

1.3 Objective

The main objective of this project is to design and construct a prototype of a handheld gas leakage detector that uses semiconductor type of gas sensor. The device will be efficient, cost effective and user friendly.

1.4 Scope of Study

The gas leakage detector is only limited to detection of flammable gas especially butane gas or also known as liquefied petroleum gas (LPG). The detector uses the semiconductor type of gas sensor, thus the study will be limited to the integration of the sensor into the circuit of the gas leakage detector.

CHAPTER 2

LITERATURE REVIEW

2.1 Theory

2.1.1 Liquefied Petroleum Gas

According to [2], Liquefied Petroleum Gas (LPG) is a mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles, and increasingly replacing fluorocarbons as an aerosol propellant and a refrigerant to reduce damage to the ozone layer. The gases are a mix of propane and butane usually with propylene and butylenes present in small concentration.

LPG is the generic name for a number of low-pressure, liquefied hydrocarbon gases. LPG are hydrocarbon products in the C3-C4 range, propane (C3H8) and butane (C4H10) constituting the components. These products can be very easily liquefied under low pressure and therefore can be handled very easily, if the gaseous are at normal temperature and pressure conditions. Precautions should be taken in order to avoid long term exposure, even if it is not toxic [3]. The characteristic of LPG are:

- Colourless and odourless.
- Flammable.
- Non-toxic but can cause asphyxiation.
- Heavier than air.
- Approximately half the weight of water.
- Expands upon release and 1 litre of liquid will form approximately 250 litres of vapour.

2.1.2 Toxic Gas Hazard

According to [3], some gases are poisonous and can be dangerous to life at very low concentrations. Some toxic gases have strong smells like the distinctive 'rotten eggs' smell of H2S. The measurements most often used for the concentration of toxic gases are parts per million (ppm) and parts per billion (ppb). For example 1ppm would be equivalent to a room filled with a total of 1 million balls and 1 of those balls being red. The red ball would represent 1ppm.

More people die from toxic gas exposure than from explosions caused by the ignition of flammable gas. (It should be noted that there is a large group of gases which are both combustible and toxic, so that even detectors of toxic gases sometimes have to carry hazardous area approval). The main reason for treating flammable and toxic gases separately is that the hazards and regulations involved and the types of sensor required are different.

With toxic substances, (apart from the obvious environmental problems) the main concern is the effect on workers of exposure to even very low concentrations, which could be inhaled, ingested, or absorbed through the kin. Since adverse effects can often result from additive, long-term exposure, it is important not only to measure the concentration of gas, but also the total time of exposure. There are even some known cases of synergism, where substances can interact and produce a far worse effect when together than the separate effect of each on its own.

Concern about concentrations of toxic substances in the workplace focus on both organic and inorganic compounds, including the effects they could have on the health and safety of employees, the possible contamination of a manufactured end-product (or equipment used in its manufacture) and also the subsequent disruption of normal working activities.

2.1.3 Typical Areas that Require Gas Detection

According to [3], there are many different applications for flammable, toxic and oxygen gas detection. Industrial processes increasingly involve the use and manufacture of highly dangerous substances, particularly toxic and combustible gases. Inevitably, occasional escapes of gas occur, which create a potential hazard to the industrial plant, its employees and people living nearby. Worldwide incidents involving asphyxiation, explosions and loss of life, are a constant reminder of this problem.

In most industries, one of the key parts of the safety plan for reducing the risks to personnel and plant is the use of early warning devices such as gas detectors. These can help to provide more time in which to take remedial or protective action. They can also be used as part of a total integrated monitoring and safety system for an industrial plant.

2.2 Principle of Detection

2.2.1 Semiconductor Sensor

Sensors made from semiconducting materials operate by virtue of gas absorption at the surface of a heated oxide. In fact, this is a thin metal-oxide film (usually oxides of the transition metals or heavy metals, such as tin) deposited on a silicon slice by much the same process as is used in the manufacture of computer 'chips' [4].

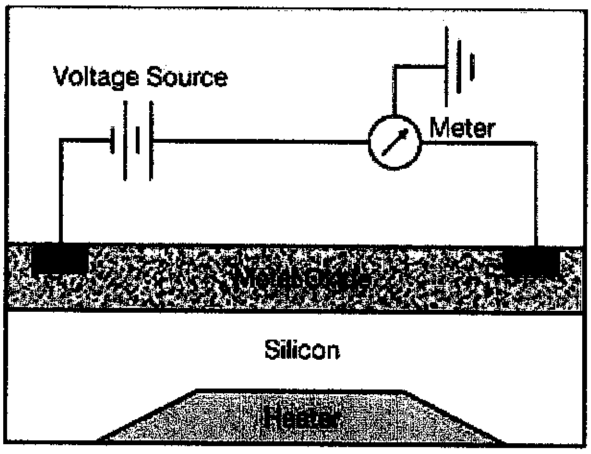

Figure 1: Semiconductor Sensor Overlay [4]

Absorption of the sample gas on the oxide surface, followed by catalytic oxidation, results in a change of electrical resistance of the oxide material and can be related to the sample gas concentration. The surface of the sensor is heated to a constant temperature of about 200-250°C, to speed up the rate of reaction and to reduce the effects of ambient temperature changes.

Semiconductor sensors are simple, fairly robust and can be highly sensitive. They have been used with some success in the detection of Hydrogen Sulphide gas, and they are also widely used in the manufacture of inexpensive domestic gas detectors. However, they have been found to be rather unreliable for industrial applications, since they are not very specific to a particular gas and they can be affected by atmospheric temperature and humidity variations. They probably need to be checked more often than other types of sensor, because they have been known to 'go to sleep' (i.e. lose sensitivity) unless regularly checked with a gas mixture and they are slow to respond and recover after exposure to an outburst of gas.

2.2.2 TGS 2600 Type of Semiconductor Sensor

Based on [5], the sensing element is comprised of a metal oxide semiconductor layer formed on an alumina substrate of a sensing chip together with an integrated heater. In the presence of a detectable gas, the sensor's conductivity increases depending on the gas concentration in the air. A simple electrical circuit can convert the change in conductivity to an output signal which corresponds to the gas concentration. The TGS 2600 has high sensitivity to low concentrations of gaseous air contaminants such as hydrogen and carbon monoxide which exist in cigarette smoke. The sensor can detect hydrogen at a level of several ppm. Due to miniaturization of the sensing chip, TGS 2600 requires a heater current of only 42mA and the device is housed in a standard TO-5 package.

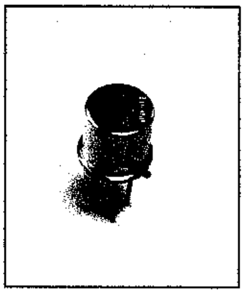

Figure 2: TGS 2600 Semiconductor Gas Sensor

2.3 Gas Detection System

2.3.1 Semiconductor Detectors

Semiconductor sensors detect gases by a chemical reaction that takes place when the gas comes in contact with the sensor. Tin dioxide is the most common material used in semiconductor sensors, and the electrical resistance in the sensor is decreased when it comes in contact with the monitored gas. The resistance of the tin dioxide is typically around 50 kΩ in air but can drop to around 3.5 kΩ in the presence of 1% methane. This change in resistance is used to calculate the gas concentration. Semiconductor sensors are commonly used to detect hydrogen, oxygen, alcohol, and harmful gases such as carbon monoxide [6].

Table 1: Advantages and Disadvantages of Semiconductor Gas Detector

Advantages	Disadvantages
- Low power consumption - High sensitivity to gaseous air contaminants - Long life and low cost - Use simple electrical circuit - Small size	- Must come in contact with the gas in order to detect it

2.3.2 Electrochemical Detectors

Electrochemical gas detectors work by allowing gases to diffuse through a porous membrane to an electrode where it is either oxidized or reduced. The amount of current produced is determined by how much of the gas is oxidized at the electrode. The sensor is then able to determine the concentration of the gas. Manufactures can customize electrochemical gas detectors by changing the porous barrier to allow for the detection of a certain gas concentration range [6]. Table 2 shows the advantages and disadvantages of electrochemical gas detectors:

Table 2: Advantages and Disadvantages of Electrochemical Gas Detector

Advantages	Disadvantages
- Cost effective protection - High sensitivity	- Sensors 'wear out' over time - Sensors can be poisoned by foreign material - Require a certain amount of humidity to correctly function

2.3.3 *Infrared Point Detectors*

Infrared point sensors (IR) use radiation passing through a volume of gas to detect leaks. Energy from the radiation is absorbed as it passes through the gas at certain wavelengths. The range of wavelengths that is absorbed depends on the properties of the specific gas. Carbon monoxide absorbs wavelengths of about 4.2-4.5 μm, for example. This is approximately a factor of 10 larger than the wavelength of visible light, which ranges from .39 μm to .75 μm for most people. The energy in this wavelength is compared to a wavelength outside of the absorption range; the difference in energy between these two wavelengths is proportional to the concentration of gas present [6]. Table 3 shows the advantages and disadvantages of infrared gas detectors:

Table 3: Advantages and Disadvantages of Infrared Gas Detector

Advantages	Disadvantages
- Fast response time - Limited maintenance required - Ideal for open areas without obstructions	- Cannot measure non hydrocarbons

2.4 Selection of Method

Based on the readings and comparison made, the author decided to use the semiconductor type of gas sensor for the gas leakage detector. The constructed gas leakage detector is handheld, thus it can be simply carried.

The LPG gas that is going to be used for the experiment purpose is butane gas, since it is easily obtained and meets the gas preference for the semiconductor gas sensor.

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

The flow of this project is shown as figure below:

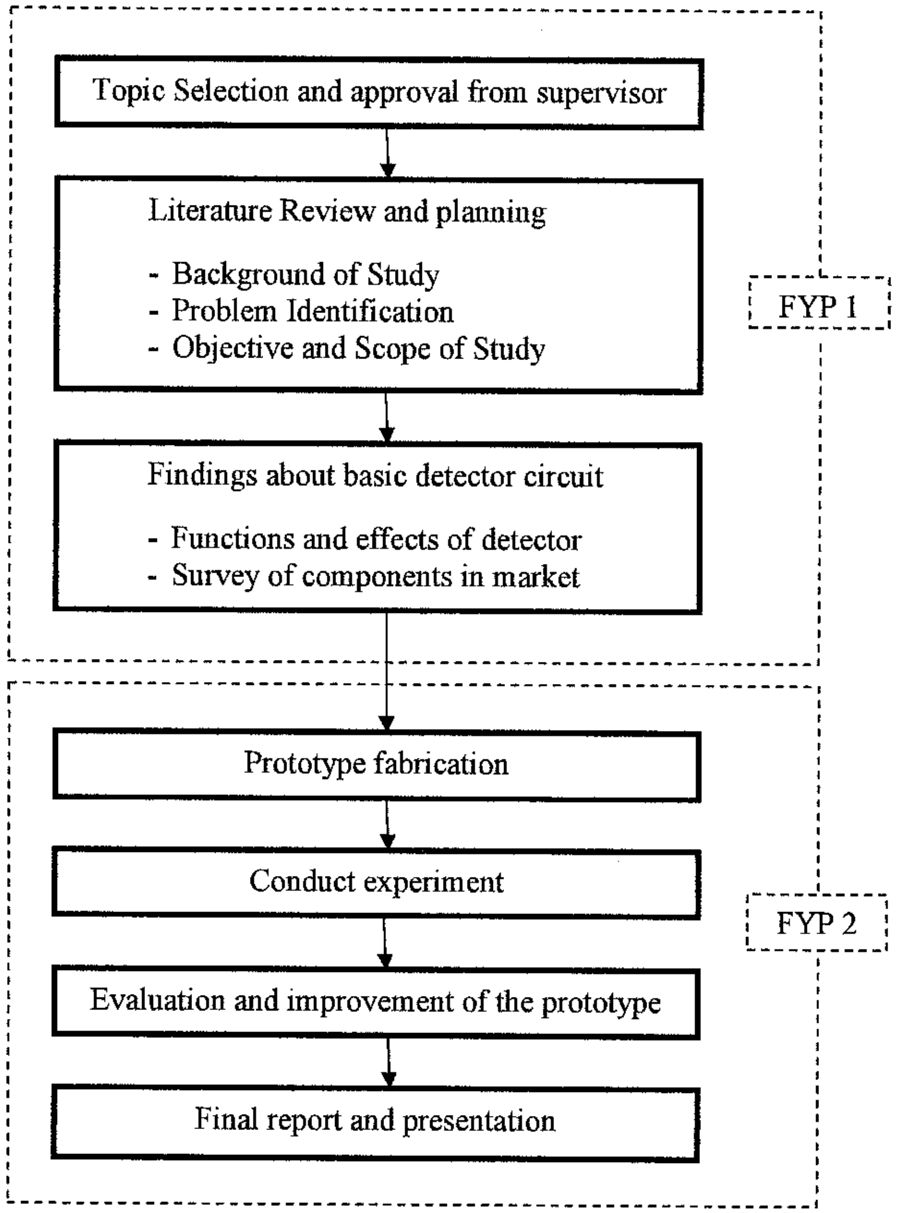

Figure 3: Project Work Flow Diagram

3.2 Circuit Design

3.2.1 System Overview

Figure 4 below shows the system overview of the handheld gas leakage detector.

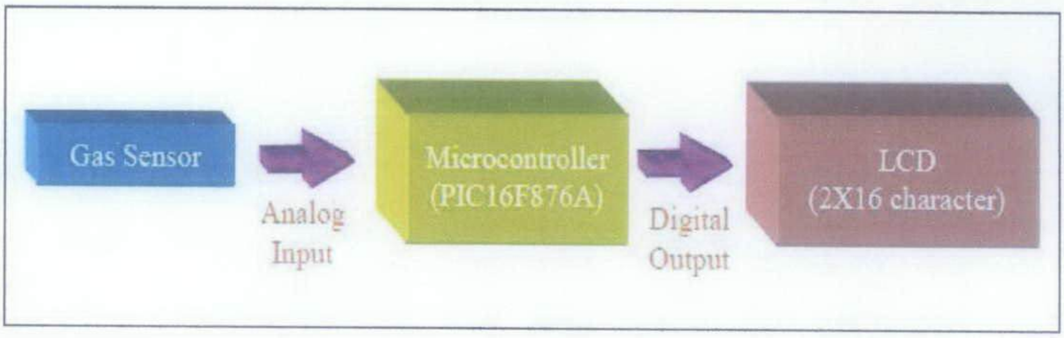

Figure 4: System Overview of Gas Detector

Basically, when the gas sensor detects the presence of gas, it gives the analog input into the microcontroller. The gas sensor act like a potential meter, where its resistances change according to the gases various concentrations. Then, the microcontroller gives digital output to be displayed at LCD. The resistance value on the LCD changes once the sensor detects the presence of gas. The microcontroller acts as the brain of the system, where it integrates the gas sensor response to be displayed on the system.

3.2.2 Schematic Diagram

Figure 5 shows all the connections between the components and power supply of the gas detector.

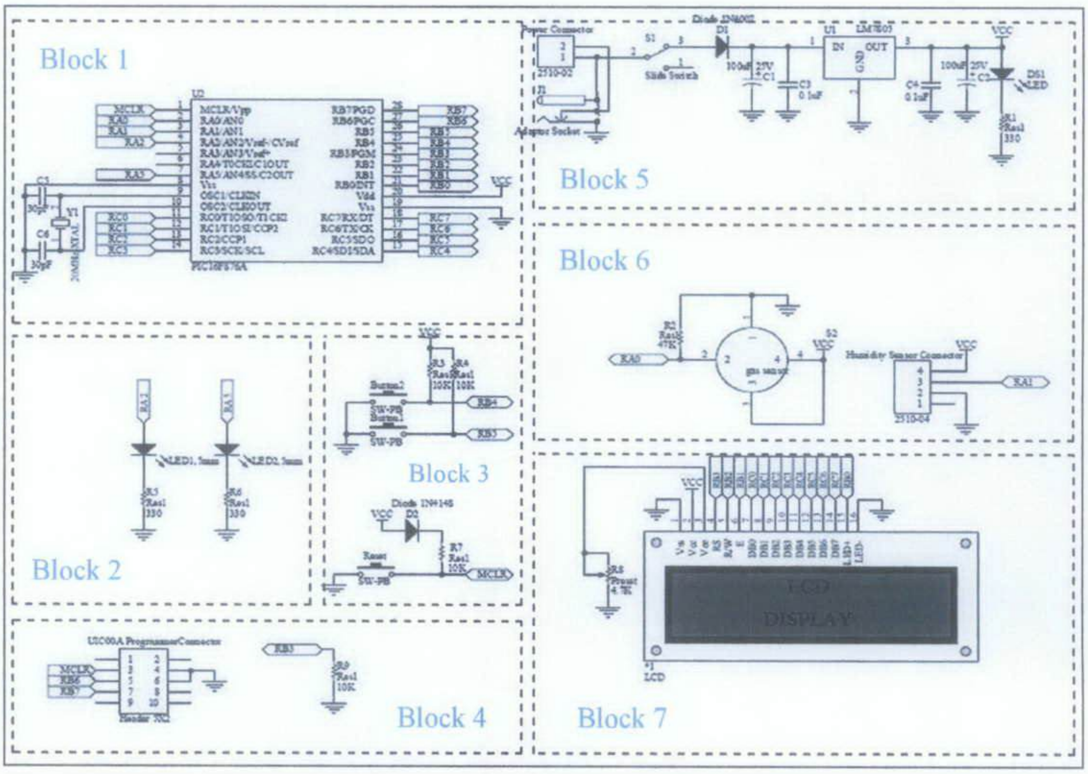

Figure 5: Overall Schematic Diagram

Below are the names of the parts in the overall schematic diagram:

1. Block 1: Control Unit (PIC)
2. Block 2: LED as output of PIC microcontroller
3. Block 3: Push Button as input of PIC microcontroller
4. Block 4: ICSP for programming PIC microcontroller
5. Block 5: Power supply for circuit
6. Block 6: Interface Gas Sensor with PIC16F876A
7. Block 7: Interface LCD (2x16 character) with PIC16F876A

The description of each of the blocks that represents the whole system of the gas leakage detector is explained below:

1. <u>Block 1: Control Unit (PIC)</u>

The PIC microcontroller used in the circuit is PIC16F876A type, 8-bit microcontroller with 22 Input/Output. It operates with 5V supply at operating speed 20MHz. The PIC is installed with the program that will read the gas sensor and display the gas reading on the LCD.

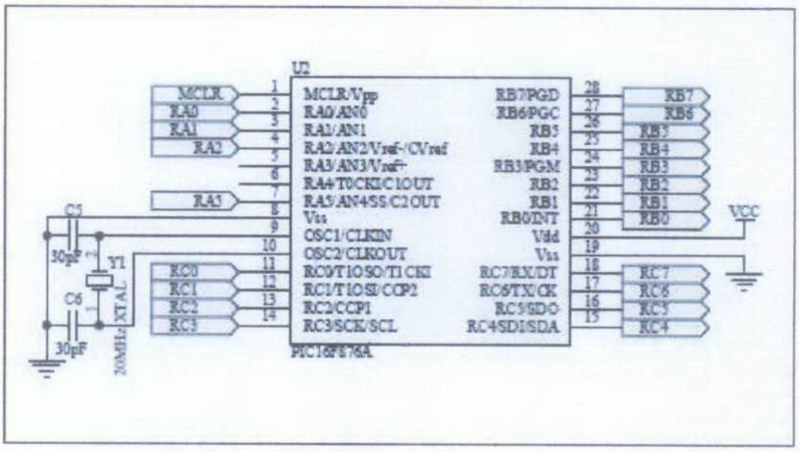

Figure 6: PIC Microcontroller

2. <u>Block 2: LED as output of PIC microcontroller</u>

One I/O pin is designated for a LED as output of PIC microcontroller. The connection for a LED to I/O pin is shown in Figure 9. The function of R11 is to protect the LED from over current which will burn the LED. When the output is in logic 1, the LED will ON, while when the output is in logic 0, the LED will OFF.

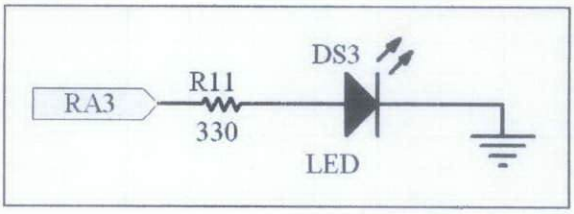

Figure 7: LED Configuration

3. <u>Block 3: Push Button as input of PIC microcontroller</u>

One I/O pin is designated for a push button as input to PIC microcontroller. The connection of the push button to the I/O pin is shown in figure below. The I/O pin should be pull up to 5V using a resistor (with value range 1K-10K) and this configuration will result an active-low input. When the button is being pressed, reading of I/O pin will be in logic 0. When the button is not pressed, reading of that I/O pin will be logic 1.

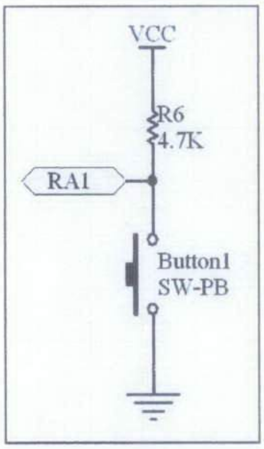

Figure 8: Push Button

4. <u>Block 4: ICSP for programming PIC microcontroller</u>

MCLR, RB6 and RB7 need to be connected to the USB in Circuit Programmer (UIC00A) to program the PIC microcontroller.

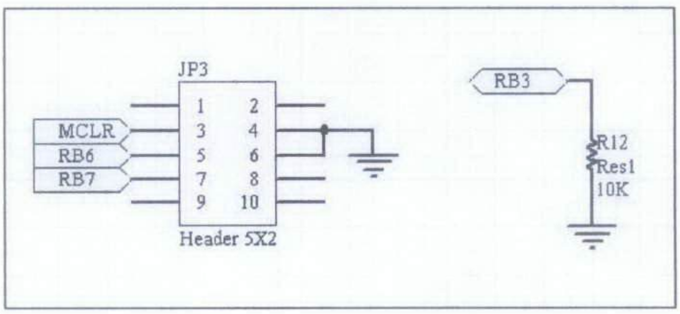

Figure 9: ICSP

5. Block 5: Power supply for circuit

D2 is use to protect the circuit from wrong polarity supply. C7 and C11 is use to stabilize the voltage at the input side of the LM7805 voltage regulator, while the C8 and C12 is use to stabilize the voltage at the output side of the LM7805 voltage supply. R13 is resistor to protect LED from over current which might burn LED.

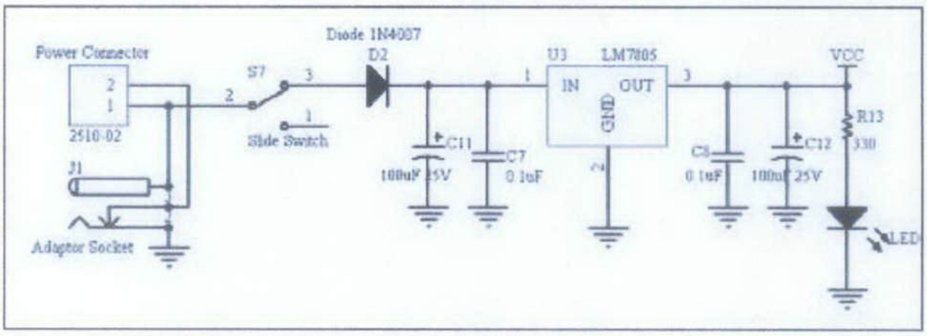

Figure 10: Power Supply for Circuit

6. Block 6: Interface Gas Sensor with PIC16F876A

The gas sensor needs a 5V supply to operate. In this case the gas sensor act like a potential meter. Its resistances change according to the gases various concentrations. Figure below shows the integration of TGS 2600 gas sensor used in the circuit of gas detector. See Appendix D for the sensor details.

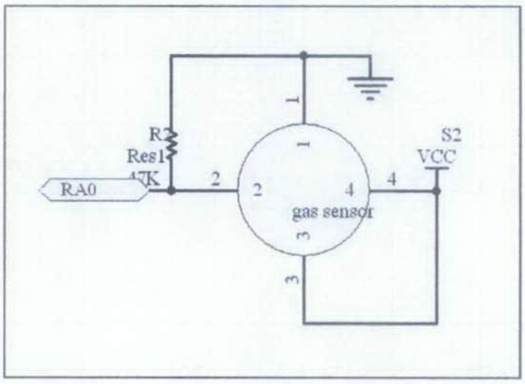

Figure 11: Integration of Gas Sensor in the Circuit

7. <u>Block 7: Interface LCD (2x16 character) with PIC16F876A</u>

The LCD used for the device is 2x16 character display and it operates at 5V supply. The LCD displays the value of resistance of the circuit. The resistance value on the LCD changes once the sensor detects the presence of gas, where its resistances change according to the gases various concentrations.

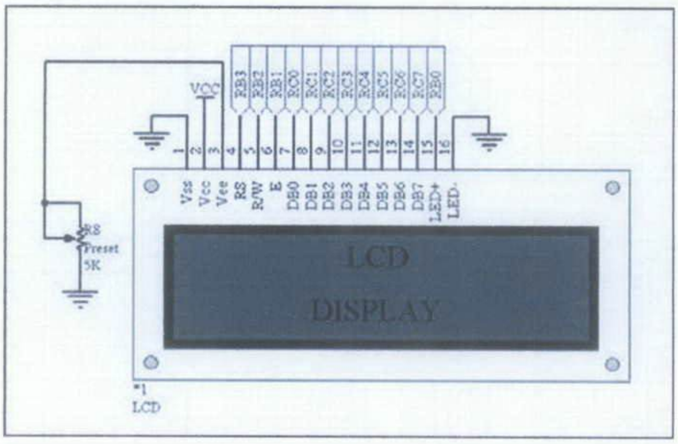

Figure 12: Interface LCD

3.3 Tools and Equipments Required

Some of the hardware and software required for this project are shown in the table below:

Table 4: Tools and Equipments Required for Gas Detector

Hardware	Software
- Gas Detector Circuit - LPG Source (Butane) - Power Supply	- Pspice - CCS C Compiler

In order to test the prototype, a Liquefied Butane cartridge is used in this study for the LPG test as shown in figure below. This gas cartridge is often used for portable cooking stove purpose.

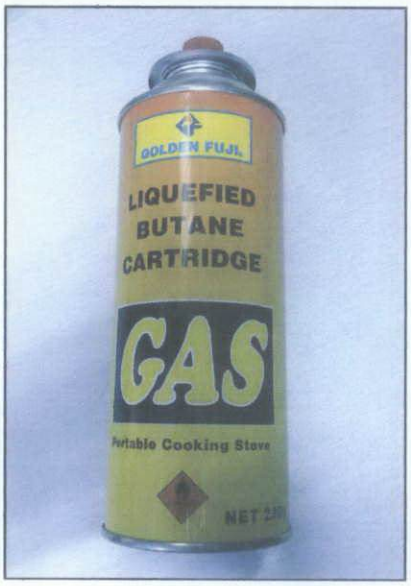

Figure 13: Liquefied Butane Cartridge

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Circuit Construction

The circuit of the gas leakage detector has been constructed on the PCB board. Below figure shows the complete circuit of the gas leakage detector:

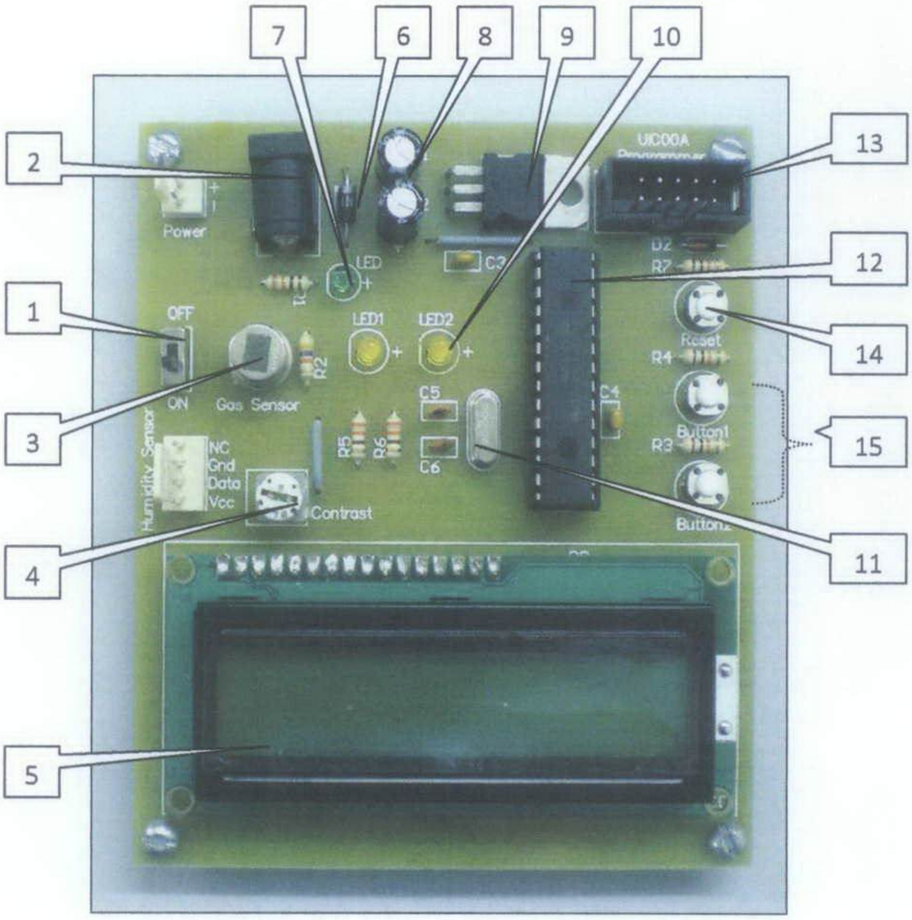

Figure 14: The Components of Gas Leakage Detector

Below is the list of components of the gas leakage detector:

1. Slide switch (to ON or OFF the circuit)
2. AC-DC adaptor socket (to use power supply from AC-DC adaptor).
3. Gas sensor
4. Preset (to adjust the brightness of the LCD)
5. LCD
6. Diode (to protect the circuit from wrong polarity power input)
7. Power indicator LED (to indicate the power status of the circuit)
8. Capacitor (to stabilize the output voltage of the LM7805 voltage regulator)
9. LM7805 (voltage regulator, supply 5V for PIC)
10. LED
11. Crystal (20MHz)
12. PIC 16F876A (the main brain of the system)
13. ICSP box header (to connect to PIC programmer to program the microcontroller)
14. Reset button (to reset the microcontroller)
15. Push button

4.2 Experimental Result

LPG tests have been conducted by supplying an amount of the LPG gas (butane) into the prototype and monitor the reaction between the prototype and the gas. The initial value displayed on the LCD is ~200, and the maximum value is ~252.

Figure 15: Gas Leakage Detector Circuit

Figure 16: Initial Reading (No Gas)

The first experiment was conducted with the gas source is placed in with no distance from the gas sensor. Table below shows the result in terms of time taken for the gas sensor to detect gas and the value of gas displayed in the LCD.

Table 5: Experiment Result with the Presence of Butane Gas (No Distance)

No. of Experiment	Time taken for gas sensor to detect gas (second)	Value displayed on LCD
1	1.0	252
2	1.5	252
3	1.0	250
4	1.5	252
5	1.0	252
Average	**1.2**	**251.6**

The variance in values displayed on LCD is due to the different amount of gas supplied to the surrounding each time the experiment is conducted. After five tests have been done, the average amount of time taken for the gas sensor to detect gas is 1.2 seconds.

Figure 17: Reading on LCD after Gas is released

Also, similar experiments have been conducted by varying the distance between the gas source and the gas sensor. This was done to test the difference of time taken for the gas leakage detector to detect the presence of gas. The gas sensor was placed 5 cm and 10 cm away from the gas source. Table below shows the results of this experiment:

Table 6: Experiment Results with the Presence of Butane Gas (Different Distances)

No. of Experiment	Distance = 5 cm		Distance = 10 cm	
	Time taken to detect gas (second)	Value displayed on LCD	Time taken to detect gas (second)	Value displayed on LCD
1	2.0	250	3.0	250
2	2.0	252	2.5	251
3	1.5	252	2.5	250
4	1.5	251	3.0	250
5	2.0	250	3.0	251
Average	**1.8**	**251**	**2.8**	**250.4**

4.3 Discussion

Based on the results shown in Table 5 and Table 6, we can conclude that the value of LCD will change when the gas sensor detects gas. This is because the gas sensor's resistance change according to the gases various concentrations. The microcontroller had converted the analog value of the gas sensor into digital value, thus when the resistance value change, the LCD reading also change.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

As a result of the experiment conducted using the semiconductor type of gas sensor for the gas leakage detector, we can see that the device can simply respond to the gas. The gas sensor's resistance change according to the gases various concentrations, thus the value of LCD will change when the gas sensor detects gas. This is because the microcontroller had converted the analog value of the gas sensor into digital value.

From the results obtained, the objective of this project which is to design and construct a prototype of a handheld gas leakage detector that uses semiconductor type of gas sensor had been achieved. The device is efficient, cost effective and user friendly. This project is a good approach for detecting at home, plant as well as industry.

5.2 Recommendations

Although this project has achieved its objective, it still can be enhanced, so it is recommended to add an alarm system or buzzer to alert the user and other people in any case that gas leakage occurs.

The detector also can be upgraded to multi-gas sensor so that more type of gases can be detected, not just limited to LPG gas.

Besides that, gas humidity sensor also can be integrated into the gas leakage detector to further improve the functionality of the device.

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APPENDIX A

Gantt Chart for FYP 1

NO	ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	FYP Briefing															
2	Selection of Project Title															
3	Preliminary Research Work															
4	Submission of Preliminary Report															
5	Research Work Continues															
6	Design															
7	Submission of Progress Report															
8	Seminar															
9	Material & Software Selection															
10	Circuit Construction & testing															
11	Submission of Draft Report															
12	Submission of Interim Report															
13	Oral Presentation															

APPENDIX B

GANTT CHART FOR FYP II

No.	ACTIVITIES	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Project Work Continue															
2	Submission of Progress Report															
3	Project Work Continue															
4	Submission of Draft Report															
5	Project Work Continue							Mid-								
6	Poster Exhibition							Sem								
7	Submission of Dissertation (soft bound)							Break								
8	Submission of Technical Paper															
9	Oral Presentation															
10	Submission of Project Dissertation (Hard Bound)															

APPENDIX C

SOURCE CODE

```
//        include
//=========================================================================
#include <pic.h>                        //include PIC microcontroller library

//        configuration
//=========================================================================
__CONFIG ( 0x3F32 );                    //PIC microcontroller configuration

//        define
//=========================================================================
#define  rs                     RB3            //RS pin of LCD display
#define  rw                     RB2            //R/W pin of the LCD display
#define  e                      RB1            //E pin of the LCD display
#define  b_light        RB0                    //Backlight of LCD display (high to on)
#define  button1        RB5                    //button 1 (active low)
#define  button2        RB4                    //button 2 (active low)
#define  lcd_data  PORTC               /       /LCD display data PORT (8-bit)
#define  led1           RA2                    //led 1 (active high)
#define led2            RA5                    //led 2 (active high)

//        function prototype
//=========================================================================
void delay(unsigned long data);
void send_config(unsigned char data);
void send_char(unsigned char data);
void lcd_goto(unsigned char data);
void lcd_clr(void);
void send_string(const char *s);
void send_num(unsigned short data);
unsigned char usart_rec(void);
void beep_short(void);
void beep_short2(void);
void beep_long(void);
unsigned char read_ad(unsigned char channel);

//        global variable
//=========================================================================

//        main function
//=========================================================================
void main(void)
{
        //assign variable
        unsigned char temp;             //declare a temporary variable for reading ADC
        unsigned char mode;             //declare a variable to represent current mode

        //set I/O input output
        TRISB = 0b11110000;             //configure PORT B I/O direction
        TRISA = 0b11011011;             //configure PORT A I/O direction
        TRISC = 0b00000000;             //configure PORT C I/O direction

        //configure lcd
        send_config(0b00000001);        //clear display at lcd
        send_config(0b00000010);        //Lcd Return to home
        send_config(0b00000110);        //entry mode-cursor increase 1
        send_config(0b00001100);        //diplay on, cursor off and cursor blink off
        send_config(0b00111000);        //function set
```

```
//configure ADC
	ADCON0=0b10000001;				//enable ADC converter module
	ADCON1=0b01000100;				//configure ADC and ANx pin

	//initial condition
	b_light=1;					//on backlight
	lcd_clr();					//clear lcd
	lcd_goto(0);					//set the lcd cursor to location 0

	mode=1;						//set startup mode to mode 1
	led1=1;						//on led 1
	led2=0;						//off led 2

	while(1)					//infinity loop
	{
		if(button1==0)				//if button 1 pressed
		{
			mode=1;				//set to mode 1
			led2=0;				//off led 2
			led1=1;				//on led 1
		}
		else if(button2==0)			//else if button 2 pressed
		{
			mode=2;				//set to mode 2
			led1=0;				//off led 1
			led2=1;				//on led 1
		}

		if(mode==1)				//if mode = 1
		{
			lcd_goto(0);			//set lcd cursor to location 0
			send_string("Gas Sensor  "); //display "Gas Sensor"
			temp=read_ad(0);		//read AN0 (Gas Sensor)
			lcd_goto(20);			//set lcd cursor to location 20
			send_num(temp);			//display the analog value of the gas sensor
		}
		else if(mode==2)			//if mode = 2
		{
			lcd_goto(0);			//set lcd cursor to location 0
			send_string("Humidity Sensor ");	//display "Humidity Sensor"
			temp=read_ad(1);		//read AN1 (Humidity Sensor)
			lcd_goto(20);			//set lcd cursor to location 20
			send_num(temp);			//display the analog value of the gas sensor
		}
	}
}

//	functions
//==========================================================================

void delay(unsigned long data)			//delay function, the delay time
{
	//depend on the given value
	for( ;data>0;data-=1);
}

void send_config(unsigned char data)		//send lcd configuration
{
	rw=0;						//set lcd to write mode
	rs=0;						//set lcd to configuration mode
	lcd_data=data;					//lcd data port = data
	e=1;						//pulse e to confirm the data
	delay(50);
```

```
	e=0;

	delay(50);
}

void send_char(unsigned char data)			//send lcd character
{
	rw=0;					//set lcd to write mode
	rs=1;					//set lcd to display mode
	lcd_data=data;				//lcd data port = data
	e=1;					//pulse e to confirm the data
	delay(10);
	e=0;
	delay(10);
}

void lcd_goto(unsigned char data)			//set the location of the lcd cursor
{							//if the given value is (0-15) the
	if(data<16)				//cursor will be at the upper line
	{					//if the given value is (20-35) the
		send_config(0x80+data);		//cursor will be at the lower line
	}					//location of the lcd cursor(2X16):
	else					// ----------------------------------------------------
	{				//| |00|01|02|03|04|05|06|07|08|09|10|11|12|13|14|15| |
		data=data-20;		//| |20|21|22|23|24|25|26|27|28|29|30|31|32|33|34|35| |
		send_config(0xc0+data);		// ----------------------------------------------------
	}
}

void lcd_clr(void)					//clear the lcd
{
	send_config(0x01);
	delay(600);
}

void send_string(const char *s)			//send a string to display in the lcd
{
	unsigned char i=0;
	while (s && *s)send_char (*s++);

}


void send_num(unsigned short data)			//function to display a value on lcd display
{
	unsigned char tenthou,thou,hund,tenth;

	tenthou=data/10000;			//get tenthousand value
	data=data%10000;
	thou=data/1000;				//get thousand value
	data=data%1000;
	hund=data/100;				//get hundred value
	data=data%100;
	tenth=data/10;				//get tenth value
	data=data%10;				//get unit value

	send_char(0x30+tenthou);		//display the tenthousand value
	send_char(0x30+thou);			//display the thousand value
	send_char(0x30+hund);			//display the hundred value
	send_char(0x30+tenth);			//display the tenth value
	send_char(0x30+data);			//display the unit value
}

unsigned char read_ad(unsigned char channel)//fucntion read analog input according to the given channel
```

```
{
        unsigned char result;                          //declare a variable call result
        switch(channel)
        {
                case 0:                                //if channel = 0
                        CHS2=0;                        //CHS2=0
                        CHS1=0;                        //CHS1=0
                        CHS0=0;                        //CHS0=0
                        break;
                case 1:                                //if channel = 1
                        CHS2=0;                        //CHS=0
                        CHS1=0;                        //CHS=0
                        CHS0=1;                        //CHS=1
                        break;
        }
        ADGO=1;
        //start ADC convertion
        while(ADGO);                                   //wait for ADC convertion to complete
        result=ADRESH;                                 //read the result
        return result;                                 //return the result
}
```

GARO

PRODUCT INFORMATION

TGS 2600 - for the detection of Air Contaminants

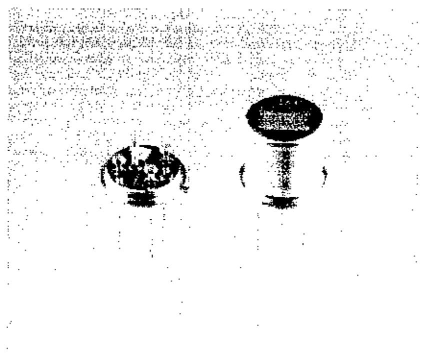
ıtures:

Low power consumption
High sensitivity to gaseous air
contaminants
Long life and low cost
Uses simple electrical circuit
Small size

Applications:

* Air cleaners
* Ventilation control
* Air quality monitors

ensing element is comprised of a metal oxide semiconductor layer formed ı alumina substrate of a sensing chip together with an integrated heater. ɘ presence of a detectable gas, the sensor's conductivity increases nding on the gas concentration in the air. A simple electrical circuit can ɜrt the change in conductivity to an output signal which corresponds to the oncentration.



ΓGS 2600 has high sensitivity to low concentrations of gaseous air minants such as hydrogen and carbon monoxide which exist in cigarette e. The sensor can detect hydrogen at a level of several ppm. Figaro also ; a microprocessor (FIC93619A) which contains special software for ing the sensor's signal for appliance control applications.

ɔ miniaturization of the sensing chip, TGS 2600 requires a heater current y 42mA and the device is housed in a standard TO-5 package.

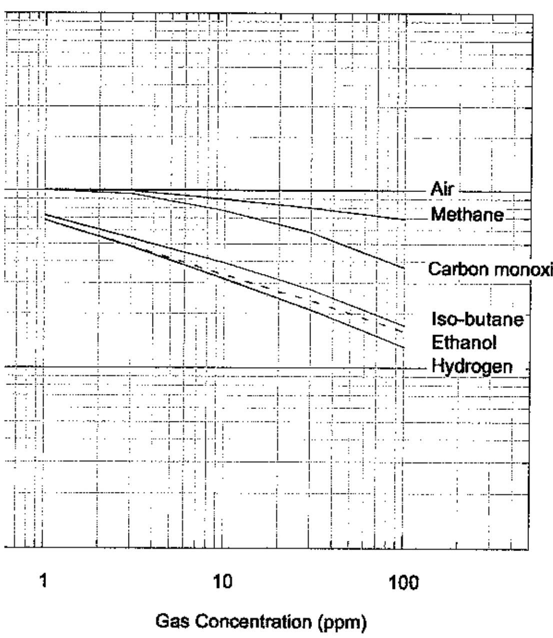
igure below represents typical sensitivity characteristics, ta having been gathered at standard test conditions (see se side of this sheet). The Y-axis is indicated as *sensor 'ance ratio* (Rs/Ro) which is defined as follows:

Rs = Sensor resistance in displayed gases at various concentrations
Ro = Sensor resistance in fresh air

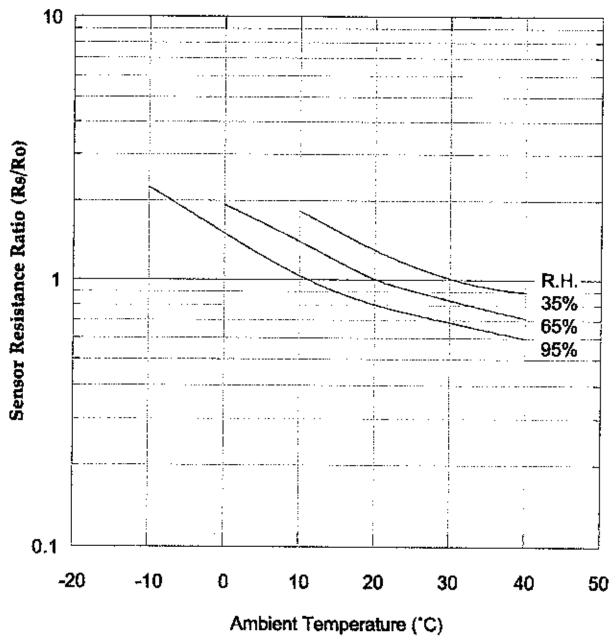
The figure below represents typical temperature and humidity dependency characteristics. Again, the Y-axis is indicated as *sensor resistance ratio* (Rs/Ro), defined as follows:

Rs = Sensor resistance in fresh air at various temperatures/humidities
Ro = Sensor resistance in fresh air at 20°C and 65% R.H.

itivity Characteristics:



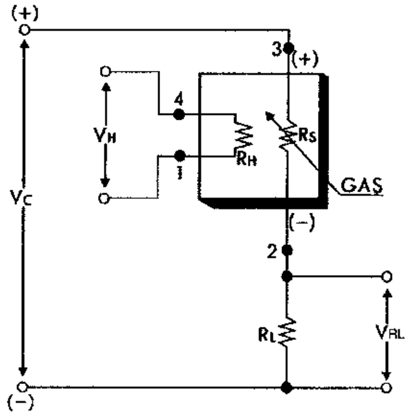
Temperature/Humidity Dependency:



ANT NOTE: OPERATING CONDITIONS IN WHICH FIGARO SENSORS ARE USED WILL VARY WITH EACH CUSTOMER'S SPECIFIC APPLICATIONS. FIGARO STRONGLY ⁄IENDS CONSULTING OUR TECHNICAL STAFF BEFORE DEPLOYING FIGARO SENSORS IN YOUR APPLICATION AND, IN PARTICULAR, WHEN CUSTOMER'S TARGET GASES ' LISTED HEREIN. FIGARO CANNOT ASSUME ANY RESPONSIBILITY FOR ANY USE OF ITS SENSORS IN A PRODUCT OR APPLICATION FOR WHICH SENSOR HAS NOT BEEN ↄALLY TESTED BY FIGARO.

;ic Measuring Circuit:

ı sensor requires two voltage inputs: ter voltage (VH) and circuit voltage). The heater voltage (VH) is applied :he integrated heater in order to ntain the sensing element at a cific temperature which is optimal sensing. Circuit voltage (Vc) is lied to allow measurement of voltage ut) across a load resistor (RL) which ɔnnected in series with the sensor. voltage is required for the circuit voltage since the sensor has a polarity. A common power supply circuit can be used for both Vc and VH to fulfill the sensor's electrical requirements. The value of the load resistor (RL) should be chosen to optimize the alarm threshold value, keeping power consumption (Ps) of the semiconductor below a limit of 15mW. Power consumption (Ps) will be highest when the value of Rs is equal to RL on exposure to gas.



cifications:

Model number			TGS 2600	
Sensing element type			D1	
Standard package			TO-5 metal can	
Target gases			Air contaminants	
Typical detection range			1 ~ 10 ppm of H_2	
tandard circuit conditions	Heater voltage	VH	5.0±0.2V DC/AC	
	Circuit voltage	Vc	5.0±0.2V DC	Ps ≤ 15mW
	Load resistance	RL	Variable	Ps ≤ 15mW
Electrical haracteristics er standard test conditions	Heater resistance	RH	approx. 83Ω at room temp. (typical)	
	Heater current	IH	42±4mA	
	Heater power consumption	PH	210mW	VH=5.0V DC
	Sensor resistance	Rs	10k~90kΩ in air	
	Sensitivity (change ratio of Rs)		0.3~0.6	Rs (10ppm of H2) / Rs (air)
;tandard test conditions	Test gas conditions		normal air at 20±2°C, 65±5%RH	
	Circuit conditions		Vc = 5.0±0.01V DC VH = 5.0±0.05V DC	
	Conditioning period before test		7 days	

ılue of power consumption (Ps) can ılculated by utilizing the following a:

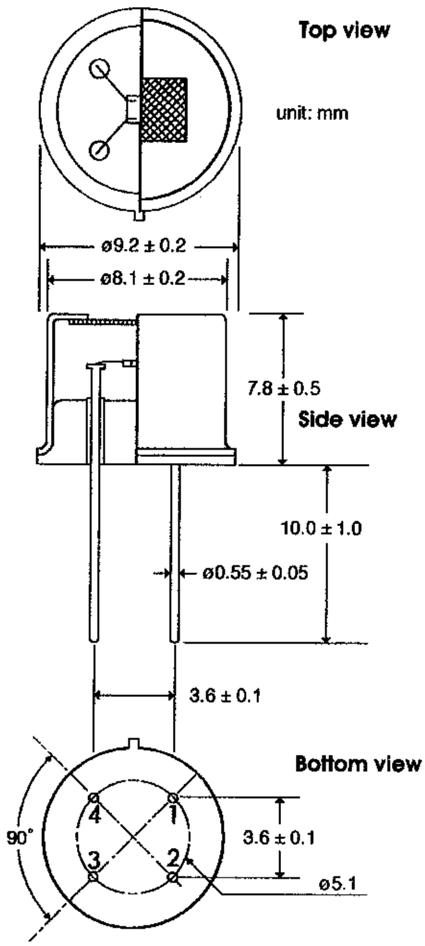
$$Ps = \frac{(Vc - Vout)^2}{Rs}$$

Sensor resistance (Rs) is calculated with a measured value of Vout by using the following formula:

$$Rs = \frac{Vc \times RL}{Vout} - RL$$

ɔrmation on warranty, please refer to Standard Terms and Conditions of Sale of USA Inc.

Structure and Dimensions:



Pin connection:
1 : Heater
2 : Sensor electrode (-)
3 : Sensor electrode (+)
4 : Heater

FIGARO USA, INC.
3703 West Lake Ave. Suite 203
Glenview, Illinois 60025
Phone: (847)-832-1701
Fax: (847)-832-1705
e-mail: figarousa@figarosensor.com

ESISTOR & CAPACITOR DATA

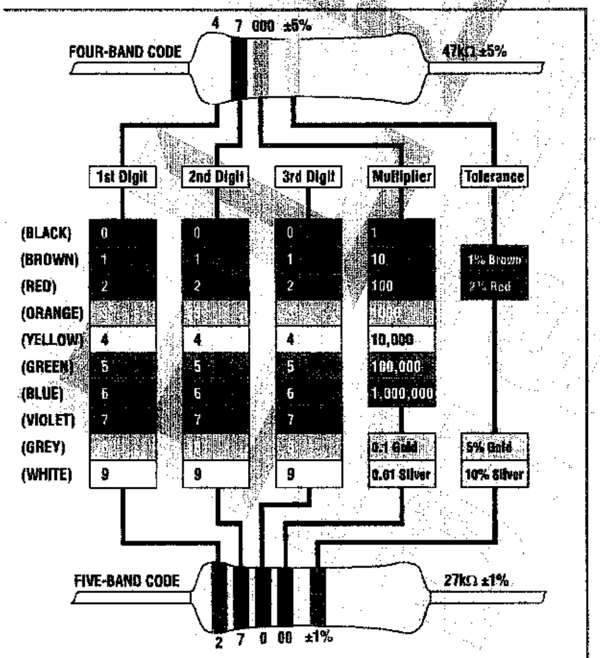
sistors

lany resistors are so small that it would be difficult to it their value and % tolerance on their body in digits. To ercome this, a coding system based on bands of tinctive colours was developed to assist in identification. rning this 'colour code' is not as necessary as it used to (thanks to accurate, low cost digital multimeters!), but not hard to learn and it's quite useful knowledge way.

he first thing to know is that in each decade of istance — i.e., from 10 - 100Ω, 100 - 1kΩ, 1k - 10kΩ, — there are only a finite number of different nominal ues allowed. Most common resistors have values in the 2' series, which only has 12 allowed values per decade. rmalised these are 1.0, 1.2, 1.5, 1.8, 2.2, 2.7, 3.3, 3.9, , 5.6, 6.8 and 8.2. Multiples of these values are simply eated in each decade — e.g., 10, 12, 15, 18 and so on. te that the 'steps' between these values are always very se to 20%, because the E12 series dates from the days of istors with ±10% tolerance.

o allow greater accuracy in circuit design, modern 1% erance resistors are made in a larger range of values: the 4' series, which has 12 *additional* allowed values per ade as shown in the table. As before, these ninal values are simply repeated in each decade. The le at right shows both the E12 and E24 allowed values comparison.

he next thing to know is that there are **two** different istor colour coding systems in use: one using a total of 4 our bands, and the other 5. The 5-band system is ierally used for 2% and closer tolerance resistors, even ugh the 4-band system is quite capable of handling any istors with E12 or E24 values. Both systems use the ne band colours to represent the various digits; the main erence is that 5-band resistors have an additional 'third id', which is almost always BLACK to represent a third it of '0'. Here's how both systems work in practice:



4-band resistors will almost always have values in the E12 series, while 5-band resistors can have any value in the E24 series. This is worth remembering, because depending on the resistor's body colour, some of the band colours may not be easy to distinguish. Blue (6) and grey (8) sometimes look very similar, as do red (2), brown (1) and orange (3). So if you're in doubt, check the apparent coded value against the allowed E12 or E24 values to see if it's 'legal' — or check with a digital multimeter, just to make sure.

Preferred Resistor Values
(within each decade)

E12 Series	E24 Series
10	10
	11
12	12
	13
15	15
	16
18	18
	20
22	22
	24
27	27
	30
33	33
	36
39	39
	43
47	47
	51
56	56
	62
68	68
	75
82	82
	91

Capacitors

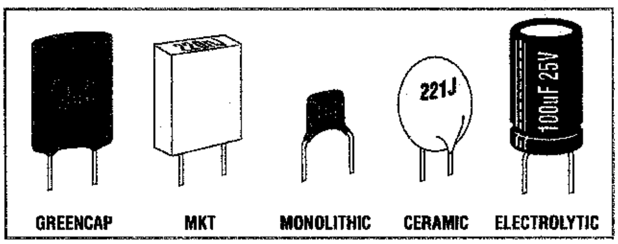
Virtually all of the capacitors stocked by Jaycar have their electrical values printed directly on their body, in digits and letters. However there's often still a coding system, which can make it a bit tricky to work out the capacitance, voltage rating, tolerance and so on until you know how it works. This is explained below.

Incidentally, so-called 'greencaps' (which can actually be brown, dark red or even blue!) are one type of metallised polyester film capacitor, like the 'MKT' type — which tends to be smaller, and in a more tightly controlled rectangular package. Similarly the 'monolithic' type is a type of multilayer ceramic capacitor, designed to combine high capacitance with very low self-inductance.

Plastic film, Ceramic & Monolithic Capacitors

Most of these types have their nominal value either printed directly on them or use the 'EIA' coding system, which is a bit like resistor colour coding, but in digits: the first two digits followed by a 'multiplier' showing the number of zeroes. With this code the value is generally given in picofarads (pF), which you'll need to divide by either one million or one thousand (respectively) if you want the value in microfarads (μF) or nanofarads (nF).

Hence a capacitor marked '104' has a value of 10 with 4 zeroes after it, or 100,000pF (which is the same as 100nF, or 0.1μF). Similarly '681' means 68 with a single zero, or 680pF, while '472' means 47 with two zeroes, or 4700pF (which is the same as 4.7nF).



Alternatively the value may be given directly in nanofarads, with three significant digits but the third generally '0'. In this case there's generally also a small 'n', which can be used in place of a decimal point. So '220n' means a 220nF capacitor, which is the same as 0.22µF, while '3n3' means 3.3nF (= 3300pF).

Many of these capacitors also have a capital letter to indicate their tolerance rating, according to the following coding system:

Capacitor Tolerance Marking Codes					
F	G	J	K	M	Z
±1%	±2%	±5%	±10%	±20%	-20%, +80%
Examples: 104K = 0.1µF ± 10%; 4n7J = 4.7nF ±5%					

Material Codes for Plastic Film Capacitors

Capacitors which use a plastic film dielectric are identified using the following codes:

MKT	Metallised Polyester (PETP)
KS	Polystyrene film/foil
MKC	Metallised Polycarbonate
KP	Polypropylene film/foil
KT	Polyester film/foil
MKP	Metallised polypropylene

Ceramic Capacitor Colour coding for Temperature Coefficient

Capacitors which use a plastic dielectric have a very low *temperature coefficient* (tempco) — i.e., their capacitance scarcely varies with temperature, and can generally be regarded as 'stable'. However this isn't true with many ceramic-dielectric types. Many of the ceramic materials produce a negative tempco, where capacitance *decreases* with temperature, while a few give a positive tempco where capacitance increases with temperature.

By careful mixing of materials, manufacturers can produce a ceramic which gives a tempco very close to zero, but the resulting dielectric constant is also quite low. That is why such 'NP0' capacitors are normally only available in relatively low values — less than about 200pF, typically.

The following colour bands are used on ceramic capacitors to indicate their tempco. Note that 'P' indicates a positive tempco and 'N' a negative one, with the number indicating parts per million per degree C.

P100	Red/Violet	**NP0**	Black
N033	Brown	**N075**	Red
N150	Orange	**N220**	Yellow
N330	Green	**N470**	Blue
N750	Violet	**N1500**	Orange/Orange

Electrolytic Capacitors

Electrolytic capacitors take advantage of the ability of some metal oxides to act as an excellent insulator (at low voltages) and also form a dielectric material with a very high dielectric constant 'K'. Most common electrolytic capacitors use aluminium oxide as the dielectric, but special-purpose and low-leakage types generally use tantalum oxide.

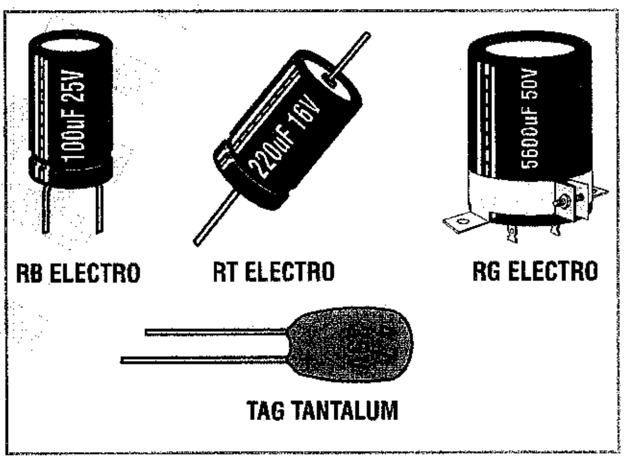
The main shortcoming of electrolytic capacitors is that the insulating and dielectric properties of the metallic oxides are polarity sensitive — so most electrolytic capacitors must be connected into circuit so that voltage is always applied to them with the correct polarity (which is marked on their body). The only exception is 'non polarised' or *bipolar* (BP) electrolytics, which are effectively two electrolytics in series back-to-back.

Because the oxide dielectric layer in electrolytic capacitors is extremely thin, these capacitors are more prone to breakdown at higher voltages. So all electrolytics are clearly marked in terms of their safe maximum operating voltage.

In most cases electrolytics also have their capacitance value shown directly on the case as well.

The three most common types of aluminium electrolytic in current use are the axial-lead or RT type, the radial-lead or RB type (for vertical mounting on PC boards) and the chassis-mounting or RG type. There's also a variation on the RB type called the RP, with a third lead for orientation and added support.

The most common type of tantalum electrolytic in current use is the solid or TAG tantalum type, where the tantalum oxide dielectric is formed on the surface of a solid block of sintered tantalum granules. These capacitors provide low leakage and very high capacitance in a very small volume, but are limited to quite low voltages — typically less than 33V.



CHEMICAL SAFETY DATA SHEET

RISALAH DATA KESELAMATAN KIMIA

Natural Gas

Gas Asli

The Occupational Safety & Health Act 1994 (*Use and Standard of Exposure of Chemical Hazardous to Health, USECHH*) Regulations 2000 - Part VII, Section 25; prescribes that Chemical Safety Data Sheet (CSDS) shall be kept in a conspicuous place close to each location where that chemical is used, and shall be easily accessible to the employees.

Akta Keselamatan & Kesihatan Pekerjaan 1994; Peraturan-Peraturan (*Penggunaan dan Standard Pendedahan Bahan Kimia Berbahaya Kepada Kesihatan, USECHH*) 2000 – Bahagian VII, Seksyen 25; menyatakan bahawa Risalah Data Keselamatan Kimia (CSDS) hendaklah diletakkan di tempat yang mudah dilihat berdekatan dengan setiap lokasi bahan kimia itu digunakan, dan hendaklah mudah diperolehi pekerja.

SECTION 1: CHEMICAL PRODUCT & COMPANY IDENTIFICATION
SEKSYEN 1: PENGENALPASTIAN PRODUK KIMIA DAN SYARIKAT

Product Details / *Maklumat Produk*

Product Name *Nama Produk*	:	**NATURAL GAS** *GAS ASLI*
Trade Name *Nama Dagangan*	:	Natural Gas *Gas Asli*
Chemical Name *Nama Kimia*	:	Methane, Ethane *Metana, Etana*
Chemical Formula *Formula Kimia*	:	CH_4, C_2H_6
Molar Mass *Jisim Molar*	:	16.0, 30.0
Chemical Family *Kumpulan Bahan Kimia*	:	Hydrocarbons *Hidrokarbon*
Manufacture's Code *Kod Syarikat Pengeluar*	:	-
Applications *Kegunaan*	:	Fuel for industrial, commercial & residential. *Bahan bakar untuk industri, komersil dan rumah kediaman.*

Company Identification / *Pengenalpastian Syarikat*

Manufacturer's Name and Address *Nama dan Alamat Syarikat Pengeluar*	:	**Petronas Gas Bhd** Level 49-51, Tower 1, Petronas Twin Towers Kuala Lumpur City Centre 50088 Kuala Lumpur
Importer's/Distributor's Name and Address *Nama dan Alamat Pengimport/Pengedar*	:	**Gas Malaysia Sdn Bhd** No. 5, Jalan Serendah 26/17 Section 26 40732 Shah Alam Selangor Darul Ehsan.
Telephone Number *Nombor Telefon*	:	03 – 5192 3000
Emergency Telephone Number *Nombor Telefon Kecemasan*	:	1-800-88-9119

CHEMICAL SAFETY DATA SHEET
RISALAH DATA KESELAMATAN KIMIA
Natural Gas
Gas Asli

Contact Point/ *Titik Hubungan*

Designation *Jawatan*	: On duty Shift Supervisor *Penyelia Syif yang bertugas*
Department *Jabatan*	: Operations Control Room *Bilik Kawalan Operasi*
Telephone number *Nombor Telefon*	: 03-5192 6794

NOTE: The contact point given should direct a caller to someone who can clarify information or provide further information and/or a bibliography of the product.
NOTA: Titik hubungan yang diberi hendaklah terus dari pemanggil ke orang yang boleh memberi maklumat atau menyediakan maklumat tambahan dan/atau bibliografi mengenai produk tersebut.

SECTION 2: COMPOSITION/INFORMATION ON INGREDIENTS
SEKSYEN 2: KOMPOSISI & MAKLUMAT BAHAN

Chemical Name *Nama Kimia*	***CAS no.** *No. CAS**	**Proportion** *Komposisi*	**Exposure Limit (OSHA PEL)** *HAD DEDAHAN (OSHA PEL)*	**Toxicity Data (ACGIH TLV)** *DATA TOKSIK (ACGIH TLV)*
a) Methane *Metana*	74-82-8	92.73%	Not applicable *Tidak berkaitan*	Non-toxic *Bukan toksik*
b) Ethane *Etana*	74-84-0	4.07%		
c) Other hydrocarbons *Lain-lain hidrokarbon*		3.20%		

** CAS - Chemical Abstracts Service / Nombor Pendaftaran Bahan Kimia*

SECTION 3: PHYSICAL & CHEMICAL PROPERTIES
SEKSYEN 3: SIFAT-SIFAT FIZIKAL DAN KIMIA

Appearance *Rupa*	:	Colourless gas *Gas tidak berwarna*
Odour *Bau*	:	Pungent Odour - Mercaptan mixture (added) *Bau busuk - Ditambah dengan campuran Mercaptan*
Solubility *Kebolehlarutan*	:	Negligible *Diabaikan*
Boiling Point *Takat didih*	:	- 162°C
Melting Point *Takat Lebur*	:	Not applicable *Tidak berkaitan*
Vapour Pressure *Tekanan wap (mm Hg pada 25°C)*	:	Not applicable *Tidak berkaitan*
Percentage Volatiles *Kadar meruap (isipadu)*	:	Not applicable *Tidak berkaitan*
Evaporation Rate *Kadar penyejatan*	:	Not applicable *Tidak berkaitan*
Vapour Density *Ketumpatan wap*	:	0.747 kg/Sm^3@ 760 mm Hg
Specific Gravity *Graviti tentu*	:	0.61 @ 760 mm Hg
Flash Point *Takat kilat*	:	- 187 °C
Auto Ignition Temperature *Suhu pengautocucuhan*	:	537 °C
Flammable Limit *Had kemudahbakaran*	:	UEL = 15.4% vol. LEL = 4.5% vol.

SECTION 4: HAZARD IDENTIFICATION
SEKSYEN 4: PENGENALPASTIAN BAHAYA

Product Classification *Klasifikasi Produk*	:	Extremely Flammable *Amat mudah terbakar*
Effects Of Exposure *Kesan Dedahan*	:	Eyes: Natural gas is not irritating to eyes. *Mata: Gas asli tidak merengsakan mata.* Skin: Natural gas is not irritating to skin. *Kulit: Gas asli tidak merengsakan kulit.* Inhalation: Asphyxiant (dizziness), extremely over exposure may produce anaesthesia, unconsciousness and respiratory arrest. *Sedutan: Kesesakan nafas, dedahan yang terlampau menyebabkan kekebasan, tidak sedar diri dan kesesakan nafas.*

SECTION 5: FIRST AID MEASURES
SEKSYEN 5: LANGKAH-LANGKAH PERTOLONGAN CEMAS

Ingestion *Termakan*	:	Not applicable *Tidak berkaitan*
Eye contact *Sentuhan mata*	:	Not applicable *Tidak berkaitan*
Skin contact *Sentuhan kulit*	:	Not applicable *Tidak berkaitan*
Inhalation *Sedutan*	:	If inhaled, remove to fresh air area immediately. If breathing ceased, administer respiration by oxygen. Get medical attention immediately. *Sekiranya tersedut, segera beredar ke kawasan yang berudara segar. Jika pernafasan terhenti, beri bantuan pernafasan dengan oksigen. Segera dapatkan rawatan perubatan.*

SECTION 6: FIRE FIGHTING MEASURES
SEKSYEN 6: LANGKAH-LANGKAH PENCEGAHAN API

Extinguishing Media *Media pemadaman*	:	Dry chemical, carbon dioxide and water spray. *Serbuk kimia kering, karbon dioksida dan semburan air.*
Fire Fighting Instructions *Arahan pencegahan api*	:	Small Fire - use dry chemical powder. *Kebakaran kecil – guna serbuk kimia kering.* Large Fire - shut off supply, if not possible and no risk to surroundings let the fire burn itself out. *Kebakaran besar – hentikan bekalan. Jika sukar dan tiada risiko kepada persekitaran biarkan gas terus membakar.*
Special Hazards *Bahaya utama*	:	Burning or explosion may occur if the gas mixture is within the flammability limit. *Kebakaran atau letupan boleh berlaku apabila campuran gas berada di antara had kemudahbakaran.*

SECTION 7: ACCIDENT RELEASE MEASURES
SEKSYEN 7: LANGKAH-LANGKAH PENGAWALAN PELEPASAN TIDAK SENGAJA

Leak/Spill Procedure *Kebocoran / Tumpahan*	:	Eliminate all sources of ignition including internal combustion engines and power tools. Ventilate areas and avoid breathing vapour. Evacuate all unnecessary personnel from the affected area. *Jauhkan segala punca nyalaan termasuk injin pembakaran dan alatan kuasa. Kawasan tersebut hendaklah dihalang daripada dimasuki oleh orang yang tidak berkenaan.*

SECTION 8: HANDLING AND STORAGE /
SEKSYEN 8: PENGENDALIAN DAN PENYIMPANAN

Handling / Storage *Pengendalian / Penyimpanan*	:	Gas is transmitted through pipeline which is designed accordingly to ASME B31.8 & APL 5L standard. Keep away from ignition source. *Gas diagihkan melalui talian paip yang rekaannya merujuk kepada piawaian ASME B31.8 & APL 5L. Jauhkan daripada punca nyalaan.*

SECTION 9: EXPOSURE CONTROL AND PERSONAL PROTECTION
SEKSYEN 9: KAWALAN PENDEDAHAN DAN PERLINDUNGAN DIRI

Exposure Limit *Had pendedahan*	:	Not applicable *Tidak berkaitan.*
Engineering Measures/Controls *Langkah Kawalan Kejuruteraan*	:	Adequate ventilation is required. *Pengudaraan yang mencukupi diperlukan.*
Respiratory Protection *Perlindungan Pernafasan*	:	Use only with adequate ventilation. If working in confined space and oxygen concentration less than 19.5% vol., use SCBA or airline system. *Guna apabila cukup pengudaraan. Jika bekerja di dalam kawasan terkurung dan kepekatan oksigen kurang daripada 19.5%., guna SCBA atau sistem "airline".*

SECTION 10: STABILITY AND REACTIVITY
SECTION 10: KESTABILAN DAN KEREAKTIFAN

Stability *Kestabilan*	:	Stable. *Stabil.*
Condition To Avoid *Keadaan yang perlu dielak*	:	Keep away from sources of ignition. *Jauhkan daripada sumber nyalaan.*
Decomposition Product *Produk penguraian*	:	Normal combustion forms carbon dioxide and water vapour. Incomplete combustion can produce carbon monoxide. *Pembakaran normal membentuk karbon dioksida dan wap air. Pembakaran tidak lengkap akan menghasilkan karbon monoksida.*
Hazardous Polymerisation *Pempolimeran berbahaya*	:	Will not occur. *Tidak akan berlaku.*

SECTION 11: TOXICOLOGICAL INFORMATION
SEKSYEN 11: MAKLUMAT TOKSIKOLOGI

Toxicity Data *Data ketoksikan*	:	Non–toxic *Bukan toksik*
Carcinogenicity *Kekarsinogenikan*	:	Non-carcinogen *Bukan karsinogen*
Reproductive Effects *Kesan pembiakan*	:	Not determined *Tidak ditentukan*
Effects Of Overexposure *Kesan pendedahan berlebihan*	:	Not determined *Tidak ditentukan*
Chronic Effects *Kesan kronik*	:	Not determined *Tidak ditentukan*
Target Organs *Organ sasaran*	:	Not determined *Tidak ditentukan*
Medical Conditions Generally Aggravated By Exposure *Keadaan perubatan yang secara umum menjadi bertambah buruk akibat pendedahan*	:	Not determined *Tidak ditentukan*

SECTION 12: ECOLOGICAL INFORMATION
SEKSYEN 12: MAKLUMAT EKOLOGI

Mobility *Kebolehgerakan*	:	Not applicable *Tidak berkaitan*
Bioaccumulation *Pembiotumpukan*	:	Not applicable *Tidak berkaitan*
Biodegradability *Kebolehbiorosotan*	:	Not applicable *Tidak berkaitan*
Aquatic Toxicity *Ketoksikan*	:	Not applicable *Tidak berkaitan*

SECTION 13: DISPOSAL INFORMATION
SEKSYEN 13: MAKLUMAT PELUPUSAN

Disposal method in accordance with all applicable national environmental laws and regulations.
Kaedah pelupusan hendaklah mematuhi undang-undang alam sekitar kebangsaan dan peraturan-peraturannya.

SECTION 14: TRANSPORT INFORMATION
SEKSYEN 14: MAKLUMAT PENGANGKUTAN

Transportation is through pipelines in accordance with ASME B31.8 and API 5L standard.
Pengangkutan melalui talian paip adalah mematuhi piawaian ASME B31.8 dan API 5L.

SECTION 15: REGULATORY INFORMATION
SEKSYEN 15: PIAWAIAN

Risk / Safety Phrases
Ungkapan Risiko / Keselamatan

R 12	:	Extremely flammable *Amat mudah terbakar*
S 16	:	Keep away from sources of ignition - "No Smoking" *Jauhkan dari sumber pencucuhan – "Dilarang Merokok"*

SECTION 16: OTHER INFORMATION
SEKSYEN 16: MAKLUMAT LAIN

Activities not allowed within pipeline Right-of-way (ROW) perimeter, for example, excavation, planting trees, open burning, heavy vehicle parking, etc.
Aktiviti-aktiviti sepanjang perimeter hak laluan paip "ROW" tidak dibenarkan, sebagai contoh mengorek lubang, menanam pokok, pembakaran terbuka, meletak kenderaan berat dan sebagainya.

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