Science Fair Project Planning Packet

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✎	Due Dates	Things To Do
✓	18 November, 2025	Choose topic and write project question.
✓	18 November, 2025	Get approval from your teacher.
✓	1 December, 2025	Research your topic and write key words and paragraph.
✓	1 December, 2025	Write a hypothesis.
✓	15 January, 2026	Design an experiment; list variables and write procedure.
✓	15 January, 2026	List and gather your materials (bring after winter break).
✓	15 January, 2026	Conduct experiment and record data and observations.
✓	15 January, 2026	Create a table, chart, or graph of the data.
✓	15 January, 2026	Draw conclusions.
✓	15 January, 2026	Make the project display / Google Slides
✓	15 January, 2026	Write and Print Abstract
	15 January, 2026	Turn in Planning Packet to teacher / With Google Slides
	3 February, 2026	Present your project at the science fair.

→ This package is to be used as your log book.

→ The Science fair projects need to be submitted on Google slides on Google classroom.

Think of a Question - Your question will drive your entire project. Use the list of topics provided by your teacher. Make sure that your question is something that can be measured and answered by following the scientific process. Your question will also be the title of your project.

Project Question

What is the hydraulic system's response (time to execute a hydraulic function of a boom, stick and bucket cylinder of a hydraulic shovel) under extreme cold weather?

2. Research Your Topic - spend some time with your group learning more about your topic. Use reliable Internet sources, books from the library, your science book, or other resources. Do not forget to write these sources down to include in the bibliography. Not only do you want to be an expert on your topic, but you want to teach others about your topic.
    1. *Key Words* - locate 3 or more key science words related to your topic. Make sure that the words you choose are directly related to your topic. Provide a definition of each key word IN YOUR OWN WORDS.
    2. *A paragraph describing the science behind your project* - after you have completed your research give us (your audience) some background information on your topic in a complete and well-written paragraph (5-7 sentences). Give us specific, rather than general information. Use the space provided to write a draft. You will edit a final copy to place on your display board.

Key Words

Key word	Definition
Hydraulic Actuator	A device that uses pressurized hydraulic oil to create movement in machinery, such as lifting or pushing parts.

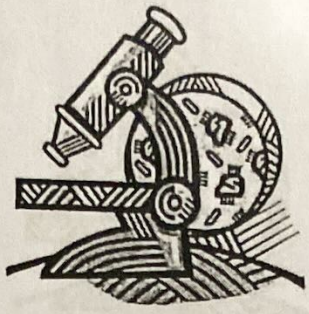
* to move its boom, stick and bucket for digging and material handling.

Hydraulic System	The system of pumps, hoses, valves, and actuators that uses pressurized fluid to move machinery parts. Eg: A hydraulic shovel is a heavy-duty excavating machine that uses hydraulic cylinders*
Hydraulic Oil	A special fluid used in hydraulic systems to transfer force and lubricate components.
Viscosity	The measure of how thick or thin a liquid is. High viscosity means thick and slow movement. Low viscosity means thin and quick movement.
Response Time	The time it takes for a hydraulic actuator to move or react after recieving a command.
Equipment Reliability	The ability of machines to perform tasks efficiently without any failure, even under harsh conditions
Fluid Resistance	The slowing down of fluid flow caused by increased viscosity, which causes the machinery to work harder.
Solenoid Valve	An eletrically controlled valve used in equipment like skid steers to quickly attach and operate implements.
Boom Restriction	A problem where the hydraulic boom of equipment, such as an equipment called the telehandler, moves slower or with less range due to the high oil viscosity.
Quick Attach Hose	A hydraulic hose used in equipment such as, skid steers to quickly attach and operate implements.
Centistokes (cSt)	A unit of viscosity, which measures a fluid's resistance to flow under gravity.
Pour Point	The lowest temperature where oil will still flow under standard test conditions.
Cold Start	First operation of equipment when system and oil are at low temperatures.
Gelling	Oil becoming semi-solid or too thick to flow well.
Elastomer	Loss of flexibility in rubber parts (hoses and seals) at low temperatures.
Downtime	The time when the equipment is not operational (broken).
Up time	The time when the equipment is operational (not broken or under repair).
AST 20	AST (All season Transmission) is a type of oil used in hydraulic systems across different temperatures. The number 20 is related to the viscosity of the oil.

Boom Extension	The process of increasing the length of a heavy machinery or equipment's arm (the boom) using hydraulic power.

Resource #1

You must have 3 Resources



Resource:

Type of Resource: Where did you list the resources?

Website: http://_____

Author: _____

Title: _____

Publishing Company: _____

Location of the Publishing Company: _____

Date of Publication: _____

Information found in your own words: What is a hydraulic system?
(Must be at least one paragraph summary.)

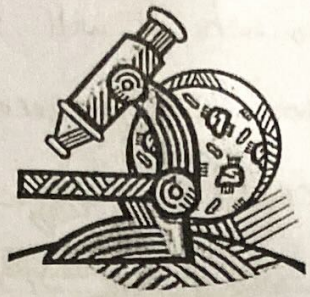
A hydraulic system is a system that uses fluid energy to work. It uses liquid oil to transmit force. This fluid energy is made by compressing hydraulic oil to generate power and control machinery and devices. It can increase a small force by dozens of times and turns it into a great force. Using the hydraulic system helps lift up or move loads easily and safely.

Examples of equipment with hydraulic systems:

A hydraulic shovel like CAT 6060 is a heavy-duty excavating machine that uses hydraulic cylinders to move its boom, stick, and bucket for digging and material handling.

Resource #2

You must have 3 Resources



Resource:

Type of Resource: _____

Website: http:// _____

Author: _____

Title: _____

Publishing Company: _____

Location of the Publishing Company: _____

Date of Publication: _____

Information found in your own words: Viscosity and Pour Point
(Must be at least one paragraph summary.)

Viscosity is the measure of how thick or thin a liquid is. High viscosity means thick and slow movement. Low viscosity means thin and fast movemen Time increases as viscosity increases. AST 20 (All Season Transmission) oil has a viscosity of 200 centistokes at -10°C, but becomes extremely thick at 10,000 centistokes at -50°C. Univis HVI 13 oil has viscosity of 60-70 centistokes at -10°C, but becomes extremely thick at 2,500-3,000 centistokes at -50°C.

The pour point is the lowest temperature where oil still flows. Below the pour point, the oil no longer pours or flows and can behave like paste or solid, which will stop the hydraulic circulation and can pervent a system from operating until the oil warms. The pour point is different from viscosity numbers but both describe cold performance and are often listed on an oil product data sheet. The pour point of the AST 20 (All Season Transmission) hydraulic oil is -45°C. The pour point of the Univis HVI 13 hydraulic oil is -57°C.

Resource #3

You must have 3 Resources

Resource:

Type of Resource: _____

Website: http:// _____

Author: _____

Title: _____

Publishing Company: _____

Location of the Publishing Company: _____

Date of Publication: _____

Information found in your own words: Viscosity and Temperature

(Must be at least one paragraph summary.)

Viscosity tells us how thick or runny a liquid is. For hydraulic oil, the viscosity tells us how easily the oil flows through pumps, valves, and hoses. When the temperature drops, the oil becomes more viscous. When it rises, the oil becomes less viscous. The viscosity increases as temperature decreases. The high viscosity makes it harder for pumps and motors to operate efficiently. This change in flow affects how fast hydraulics move. It also increases the risk of component failure. The thick oil moves tougher causing more time.

Resource #34

You must have 3 Resources

Resource:

Type of Resource: _____

Website: http:// _____

Author: _____

Title: _____

Publishing Company: _____

Location of the Publishing Company: _____

Date of Publication: _____

Information found in your own words: Problems faced by Mining Industry
(Must be at least one paragraph summary.)

- Slow boom and bucket response, delaying steering and braking response on haul trucks, incomplete cylinder movement, seal damage and hose rupture, increased pump wear and cavitation.
- Equipment Affected: Hydraulic Shovels, Skid Steer Loaders, etc...
- Components Impacted: Boom, Stick, and bucket cylinders, valves, hoses, pumps, etc...
- Results help engineers: select oil with lower pour points, reduce downtime and prevent premature component failure, improve safety by ensuring predictable control response.

Resource #5

You must have 3 Resources

Resource:

Type of Resource: _____

Website: http:// _____

Author: _____

Title: _____

Publishing Company: _____

Location of the Publishing Company: _____

Date of Publication: _____

Information found in your own words: Problems faced by Oil & Gas

(Must be at least one paragraph summary.)

- Delayed emergency valve closure, Sluggish Blowout preventer (BOP) activation, reduced pressure build-up, and system lock-up during startup
- Equipment Affected: Drilling rigs, BOP control systems, hydraulic fracturing pumps, valve actuators on pipelines.
- Components impacted: High-pressure hydraulic actuators, directional control valves, Accumulators, hydraulic power units (HPUs)
- Results can help engineers: improve emergency response reliability, design pre-heating systems for HPUs, Prevent catastrophic failures during cold starts.

Resource #6

You must have 3 Resources

Resource:

Type of Resource: _____

Website: http:// _____

Author: _____

Title: _____

Publishing Company: _____

Location of the Publishing Company: _____

Date of Publication: _____

Information found in your own words: Problem faced by Construction
(Must be at least one paragraph summary.)

• Jerky or unresponsive controls, slow lifting and dumping cycles, loss of precision when placing loads, Operator fatigue and safety risks, Increased fuel consumption during warm up.

• Equipment Affected: Excavators and backhoes, Wheel loaders, Cranes and aerial lifts, snow removal equipment.

• Components Impacted: Lift and tilt cylinders, Hydraulic control valves, Joysticks and pilot lines.

Results help engineers: Maintain productivity, reduce mechanical wear and maintenance costs, choosing oils like Univis HVI 13 for winter operations etc...

Resource #~~5~~7

You must have 3 Resources

Resource:

Type of Resource: _____

Website: http:// _____

Author: _____

Title: _____

Publishing Company: _____

Location of the Publishing Company: _____

Date of Publication: _____

Information found in your own words: Problems in extreme cold
(Must be at least one paragraph summary.)

- Hydraulic oil thickens and flows poorly, reducing responsiveness and increasing forces required.
- Quick attach hoses fail and the rubber/plastic parts become stiff and embrittle (downtime).
- Together these cause slower movements, stuck valves, leaking or burst hoses, and component damage.

Equipment affected: CAT loaders, dozers, telehandlers, can handlers, skid steers, mining shovel, etc...

Research Description (Final copy to be put on display board)

A hydraulic system is a system that uses fluid energy to work. It uses liquid oil to transmit force. This fluid energy is made by compressing hydraulic oil to generate power and control machinery and devices. It can increase a small force by dozens of times and turn it into a great force. Using the hydraulic system helps lift up or move loads easily and safely.

Examples of equipment with hydraulic systems:

A hydraulic shovel like CAT 6060 is a heavy-duty excavating machine that uses hydraulic cylinders to move its boom, stick, and bucket for digging and material handling.

Other examples are CAT 988H Loader, CAT Skid Steer Loader 279D3.

Viscosity is the measure of how thick or thin a liquid is. High viscosity means thick and slow movement. Low viscosity means thin and fast movement. Time increases as viscosity increases. ASI 20 (All Season Transmission) oil has a viscosity of 200 centistokes at -10°C, but becomes extremely thick at 10,000 centistokes at -50°C.

Univis HVI 13 oil has a viscosity of 60-70 centistokes at -10°C, but becomes extremely thick at 2,500-3,000 centistokes at -50°C. The pour point is the lowest temperature where oil still flows. Below the pour point, the oil no longer pours or flows and can behave like a paste or solid, which will stop the hydraulic circulation and can prevent a system from operating until the oil warms. The pour point is different from viscosity numbers but both describe cold performance and are often listed on an oil product data sheet. The pour point of the AST 20 (All Season Transmission) hydraulic oil is -45° C. The pour point of the Univis HVI 13 hydraulic oil is -57°C.

Viscosity tells us how thick or runny a liquid is. For hydraulic oils the viscosity tells us how easily the oil flows through pumps, valves, and hoses. When the temperature drops, the oil becomes more viscous (thicker). When the temperature rises, the oil becomes less viscous (thinner). The viscosity increases as the temperature decreases. The high viscosity makes it harder for pumps and motors to operate more efficiently and quickly. This change in flow affects how fast hydraulic systems move and its efficiency. It also increases the risk of component failure. The thick fluid/oil moves bit tough causing more time.

Faced by Mining Industry in Extreme Cold: Slow boom and bucket response during startup at -30°C to -40°C, Delaying steering and braking response on haul trucks, Incomplete cylinder movement (actuators not reaching full stroke), Seal damage and hose rupture due to high oil resistance, Increased pump wear and cavitation caused by thick oil.

Equipment Affected: Hydraulic Shovels, Skid Steer loaders, Hydraulic loaders, Hydraulic excavators, Haul Truck steering and braking systems, Underground mining bolters and loaders, etc...

Components Impacted: Boom, Stick, and bucket cylinders, Solenoid valves, Quick attach hoses, Hydraulic pumps and valves, Pilot control circuits, etc...

Results can help engineers and operators:

- Select oils with lower pour points
- Reduce downtime and prevent premature component failure
- Improve safety by ensuring predictable control response

Problems Faced by Oil and Gas Industry in Extreme Cold: Delayed emergency valve closure (critical safety risk), Sluggish BOP activation in Arctic drilling environments, Reducing pressure build-up in hydraulic circuits, Systems lock-up during startup due to thick oil.

Equipment Affected: Drilling rigs (top driver and pipe handling systems), Blowout preventer (BOP) control system, Hydraulic fracturing (frac) pumps, Valve actuators on pipe liner.

Components Impacted: High-pressure hydraulic actuators, Directional control valves, Accumulators, Hydraulic power units (HPUs)

Results can help engineers and operators: Improve emergency response reliability, Design a pre-heating system for HPUs, Prevent catastrophic failures during cold starts.

Problems Faced by Construction Industry in Extreme Cold: Jerky or unresponsive controls, Slow lifting and dumping cycles, Loss of precision when placing loads, Operator fatigue and safety risks, Increased fuel consumption during warm-up

Equipment Affected: Excavators and backhoes, Wheel loaders, Cranes and aerial lifts, Snow removal equipment

Components Impacted: Lift and tilt cylinders, Hydraulic control valves, Joysticks and pilot lines, Hydraulic pumps

Results can help engineers and operators: Maintain productivity in winter, Reduce mechanical wear and maintenance costs, Choosing oils like Univis HVI 13 for winter operation, Adjusting idle warm-up timers, Improving operator control and safety

Cold weather causes two linked problems:

- Hydraulic oil thickens and flows poorly, reducing responsiveness and increasing forces required
- Quick Attach hose fail and the rubber/plastic parts (hoses/seals)

become stiff and embrittle (down time).

- Together these cause slower movements, stuck valves, leaking or burst hoses, and component damage.

Specific examples of failures:

- Slow actuator response/limited boom extension: The cylinders move slower because the flow rate through the hydraulic system drops.
- Quick attach hose cracking and rigid fittings: Hoses become stiff and can crack when flexed. The hoses' elastomer lose elasticity in the cold, increasing the risk of failure.
- Solenoid and valves problems: Solenoid valves and control valves rely on precise movement and pressure. Thick oil delays spool movement and can prevent solenoids from actuating properly. In very low temperatures, valves can stick.
- Pump overload or wear during cold start: Pump draws harder to circulate thick oil at startup. Repeated cold starts with thick oil raises wears, increases heat generation, and cause pump failure.
- Oil "gelling" or freezing: If the oil cools below its pour point, it can stop flowing entirely and require heating before operation is possible.

Examples of real-world heavy equipment types affected:

CAT loaders, dozers, telehandlers, can handlers, skid steers, mining shovels — all use hydraulic pumps, valves, hoses, and cylinders and are related to cold related responsiveness loss and mechanical damage.

Which Oil do Manufacturers (CAT.) Recommend for cold temperatures?

Applications:

AST Fluid series are recommended for use in heavy-duty transmissions, gear boxes, differentials, final drives, wet brakes, and hydraulic systems.

AST Fluid series are also suitable for use in equipment requiring Caterpillar TO-4 and TO-4M fluids and Komatsu equipment, requiring good micro-clutch performance.

State Your Hypothesis - In your group decide what you think the outcome of the project will be and make a good guess as to what you think the answer to your question will be. **Also explain WHY you think that will be the outcome.** Remember, it is ok if you don't have the right answer; that is how scientists make discoveries. Make sure that your hypothesis is written in a complete sentence.

Hypothesis

If the hydraulic system is exposed to extremely cold temperatures, it will then experience a low functionality in the colder weather and the response time will be slower and less consistent because the hydraulic fluid (hydraulic oil) becomes thick or high in viscosity in the cold, increasing the resistance and reducing the efficiency of movement.

Design Your Experiment - Clearly write out the procedure you are going to follow. Remember that your experiment needs to follow the scientific process and that you need to have one variable that you are going to change.

1. *Materials:* List all the materials that will be used in the experiment, including the quantity for each material.
2. *Variables* - List the variables that you are going to keep the same and the one variable that you are going to change. You need to have at least one control (normal) variable and at least two to three other variables.
3. *Write your procedure* - Think through each step very carefully and list them in numbered order.

MATERIALS: Bulleted list of materials used, including specific sizes, colors, amounts, etc. Be sure to use metric units. *(Example: two Celsius thermometers, 5cm of tape)*

- Hydraulic System
- Hydraulic Oil (Ast 20)
- Stopwatch
- Thermometer which measures weather

Constant Variable What stays the same (Example: location, time out in the sun, thermometers)	Test Variable 1-ONE thing that is changed/different (Example: Aluminum can painted black, aluminum can painted white)
• Hydraulic Oil • Hydraulic System - Same motion • Same force • Same size of tubes • Same actuator (syringe) • Same volume of hydraulic oil • Same type of hydraulic oil	Manipulated Variable: Temperature Responding Variable: Response Time

PROCEDURES: Numbered list. Must begin with a *verb!* Be specific and include quantities/amounts):

Example #1: *Peel* Label off and several aluminum cans.
#2: *Place* the heat lamp 10 cm from the cans.

1:	*Gather* all materials.
2:	Assess hazards and take safety precautions (glovers and safety glasses)
3:	Assemble a toy hydraulic system — a similiare replica of CAT 6060 shovel that has boom, stick and bucket cylinder and the small tubes will act as the hydraulic hoses. Only difference is the end attachment is not a bucket.
4:	Fill the hydraulic system with AST 20 (All Season Transmission) hydraulic oil.
5:	Operate the boom, stick, and bucket cylinders using valve actuators one at a time at a given temperature.
6:	Measure the response time at each temperature.
7:	Record the readings in the data sheet.
8:	Repeat the experiment five times for all temperature conditions.
9:	Repeat the experiment with Univis HVI 13 oil and take 5 readings for same temperature readings.
10:	Record and organize the data.
11:	Analyze the results.
12:	Conclude the findings.
13:	
14:	
15:	Repeat experiment two more times for accuracy.

Conduct experiment – when you do your experiment you need to collect data and make observations. You need to complete 3 or more trials. You will complete these in your Experiment Log. After you have completed the experiment use your log to write down the data and observations below. In your log you will need to:

1. *Collect Data* - you will need to collect numerical data; that means you need to take measurements during the experiment. It can be temperature, distance, height, etc. You will analyze the data later to determine the results of your experiment.
2. *Make Observations* - as you conduct your experiment you will use your senses (sight, smell, touch, etc.) and write down any observations you make during the process.

Data-ABT 120-Response Time

		Trials					
Dates	Temperatures	Response Time 1	Response Time 2	Response Time 3	Response Time 4	Response Time 5	Average
Dec 7, 2025 (Indoor)	20°C	35 sec	34 sec	35 sec	36 sec	35 sec	35 sec
Dec 8, 2025	0°C	35 sec	37 se	37 sec	35 sec	36 sec	36 sec
Dec 11, 2025	-20°C	41 sec	43 sec	43 sec	43 sec	41 sec	42 sec
Dec 22, 2025	-30°C	45 sec	46 sec	44sec	46 sec	44sec	45 sec
Dec 28, 2025	-37°C	49 sec	48 sec	49 sec	50 sec	49 sec	49 sec

Data-Univis HVI 13 Response Time

		Trials					
Dates	Temperatures	Response Time 1	Response Time 2	Response Time 3	Response Time 4	Response Time 5	Average
Dec 7, 2025 (Indoor)	20°C	35 sec	36 sec	34 sec	34 sec	36 sec	35 sec
Dec 8, 2025	0°C	36 sec	38 sec	35 sec	35 sec	36 sec	36 sec
Dec 11, 2025	-20°C	38 sec	37 sec	38 sec	39 sec	38 sec	38 sec
Dec 22, 2025	-30°C	41 sec	40 sec	42 sec	40 sec	42 sec	41 sec
Dec 28, 2025	-37°C	42 sec	42 sec	44 sec	43 sec	44 sec	43 sec

Title: / Label:	Label: Trial 1	Trial 2	Trial 3	Average

Results: Your data written in paragraph form. You may discuss patterns and comparisons found in your data.

Sentence 1: One sentence summarizing what you were testing.
Sentence 2: Briefly explain what the data was for the **first trial**.
Sentence 3: Briefly explain what the data was for the **second trial**.
Sentence 4: Briefly explain what the data was for the **third trial**.
Sentence 5: Briefly explain the **average** of the data collected. Here is where you would make a **tatement comparing the data**, identifying the most and least quantities observed.

AST 20 has higher respone time in extreme cold temperatures as compared to Univis HVI 13 oil.

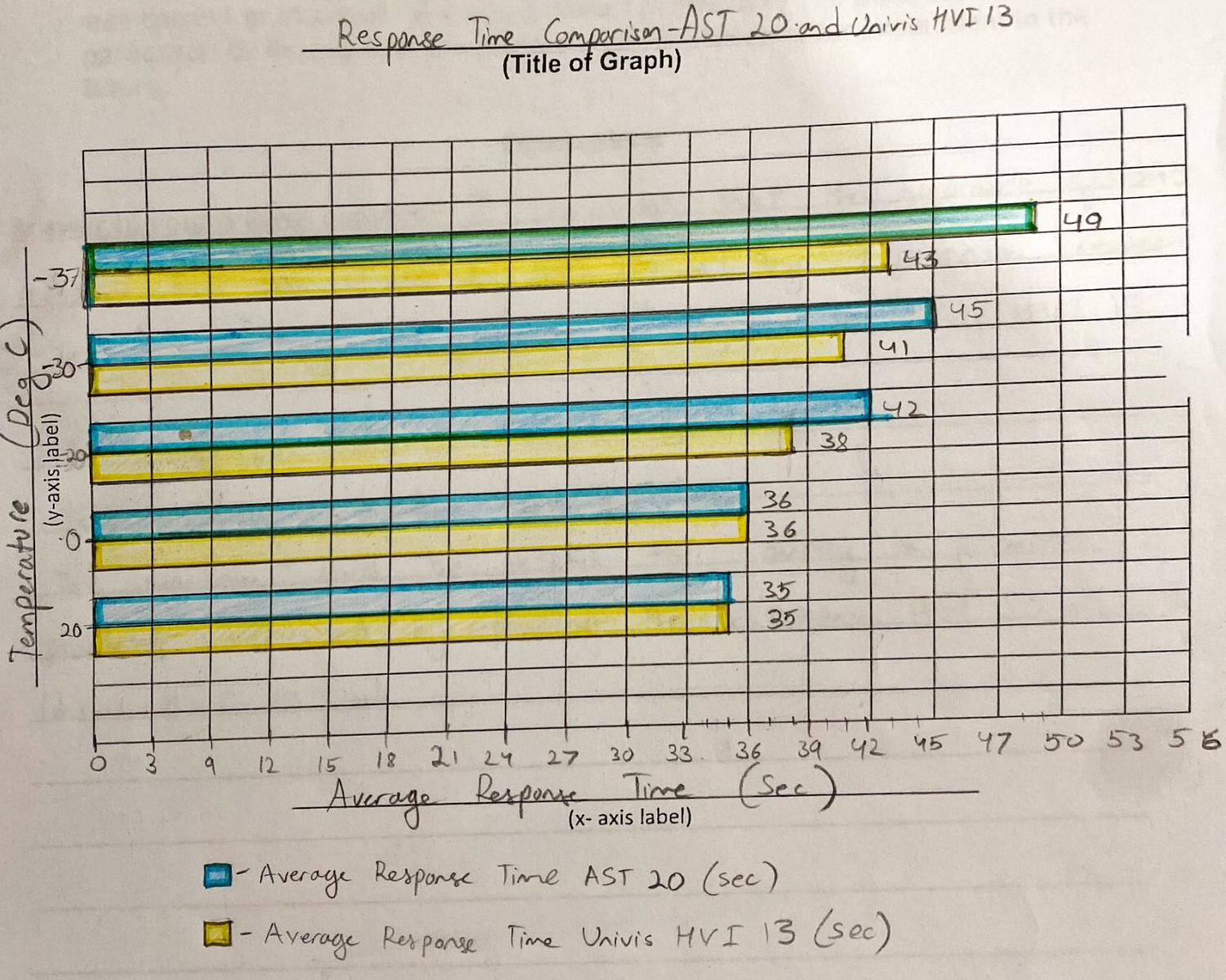
Temperatures	Average Response Time - AST 20	Average Response Time - Univis HVI 13
20°C	35 Seconds	35 Seconds
0°C	36 Seconds	36 Seconds
-20°C	42 Seconds	38 Seconds
-30°C	45 Seconds	41 Seconds
-37°C	49 Seconds	43 Seconds

Univis HVI 13 has better (lower) response time in extreme cold temperatures (below -20°C) as compared to AST 20 oil.

raph: Record **AVERAGE** data from chart into a bar graph.

- Bars must be equal widths and with equal spacing
- First bar cannot touch "0" line on the y-axis
- Select appropriate scale for y-axis (by 1's, by 2's, by 5's, or by 10's depending on your data)

Helpful website to create a graph: http://nces.ed.gov/nceskids/createagraph/



Determine the Results - Now it is time to review your data and observations to find out what happened. Think about the best way to show your data: bar graph, line graph, chart, etc. and then create a table or a graph using your data. Write out the results of each test in the experiment in paragraph form using complete sentences. Make sure that you include the numerical data (measurements) as well as any other important observations that you made.

8. Draw Conclusions - After you have determined the results it is time to decide the answer to your original question. Write your answer in a complete sentence using the question to begin your answer. You also need to tell whether your hypothesis was correct or incorrect. If it was incorrect explain why you think so. End this paragraph by saying how you could change or improve your experiment in the future.

Conclusions

Answer to your original question: I concluded that the hydraulic system's response time was slower for AST 20 oil by 4-seconds between -20 to -37 Deg C. temperatures as compared to Univis HVI 13 oil.

The conclusion matched my hypothesis.

This conclusion would be helpful to industry to prevent problems discussed by replacing the traditional AST 20 oil with Univis HVI 13 oil.

you were to complete this experiment again, what changes would you make? How would you improve this experiment?

Next time I can test more hydraulic oil types and blends.

- Investigate additional oils with different viscosity grades or low-temperature additives.
- Study blends that could maintain responsiveness across a wider temperature range.

9. Display board - Now that you have completed your experiment you will begin setting up your display board to communicate the results of your experiment to others. Remember, the board is graded on the information not how colorful or pretty it looks. Your display board must have ALL of the following components located in the same places. Other board guidelines:

- Font should be easy to read and at least a size of 16pt or greater.
- Photos should not include faces of students
- Information on the board can be typed or written neatly by hand.

Abstract – The abstract is a short version of your science fair final report. It should be no more than 250 words. Most of the information you will put in your abstract is already written, you will just need to copy it over. You must have the following five components in your abstract:

- Introduction
- Project Question
- Procedures
- Results
- Conclusions

The only new thing you will need to write it the **Introduction**. This is where you describe the purpose for doing this experiment or project. Tell why people should care about the work you did. How does your experiment give us new science information? Can this information be used to improve our lives? If so, how? This is where you want to interest the reader in your project and motivate them to read the rest of it.

Abstract Introduction

This project investigates how cold weather affects the responsiveness of hydraulic systems in heavy equipment. Two hydraulic oils, AST 20 and Univis HVI 13, were tested in a model hydraulic system at temperatures from -40°C to 20°C. The time it took for the system to complete a standard movement was measured. Results showed that colder temperatures slowed the hydraulic system because the oil became thicker, increasing resistance. Univis HVI 13 performed better than AST 20 in extreme cold, responding faster and more reliably. These findings help explain why choosing the right hydraulic oil is important in mining, construction, and oil and gas industries, improving safety, efficiency, and equipment performance in extreme cold environments.