

# Vehicle Safety Measures



**FORMULA SAE JAPAN 2024**

クルマ+ものづくりに  
熱中する学生たち

2023 Winner  
Kyoto Institute of Technology

2024.9.9 (MON) ~ 14 (SAT) Aichi Sky Expo (愛知国際展示場)

The banner features a blue and white Formula SAE car with the number 1 on its nose. The driver is wearing a white helmet with 'Arai' branding. The background shows a race track with various sponsor banners, including 'HILTI', 'VOLTEX', 'OZ', and 'KYOTO INSTITUTE OF TECHNOLOGY'. The text is overlaid on the image in a mix of English and Japanese.

## **1. Prevention of fires**

### **1.1 Fuel system**

**(1) Fuel line**

**(2) Fuel rail**

**(3) Fuel tank**

### **1.2 Engine breakage**

**(1) Poor lubrication**

**(2) Poor maintenance**

## **2. Driver thermal protection**

### **2.1 Firewalls**

## **3. Other precautions**

### **3.1 Shakedown**

# 1.Prevention of fires: 1.1-(1)Fuel line (clamp/joint)



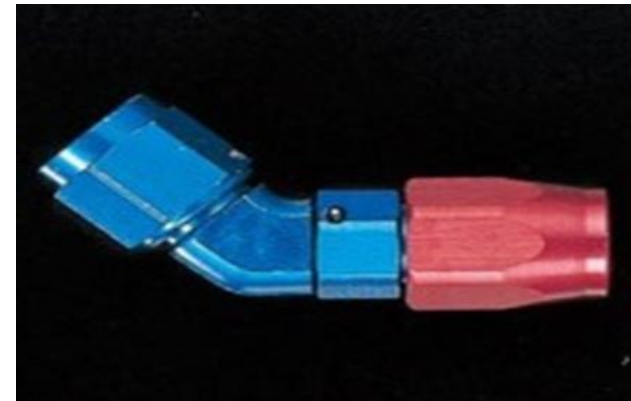
In order to prevent a fire accident, the first thing to do is not to leak fuel It is the "fitting" part that is prone to leakage, so we recommend the following

IC.5.7.4 Conformance  
Fuel hose clamp



No loosening required for clamps

IC.5.7.4 (IC.6.2.3) Conformance  
Joint



IC.5.7.5 Non-conformance (not available)  
Fuel hose clamp



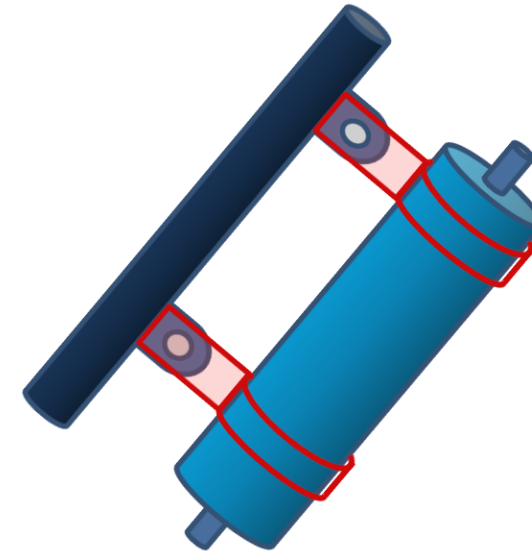
Can be used where there is  
no pressure such as return

\* There are fire reference cases

# 1.Prevention of fires: 1.1-(1) Fuel line (fuel pump)



If the fuel pump is loosely fastened, vibration can cause fuel leakage from the fittings. Secure it with clamps.



Example of clamp of fuel pump.

# 1.Prevention of fires : 1.1-(1) Fuel line (leak check)



washing



osmosis



developing

When a developer for staining penetrant testing is used, even a slight bleeding can be detected at an early stage. Originally, it mainly detects cracks in metals.

It is used in the order of washing (yellow>), penetration (red), washing (yellow> > development (light blue).

The developer sucks out the penetrant that has soaked into the crack and checks for scratches.

Only this developer can be used to detect oozing gasoline, oil, etc.

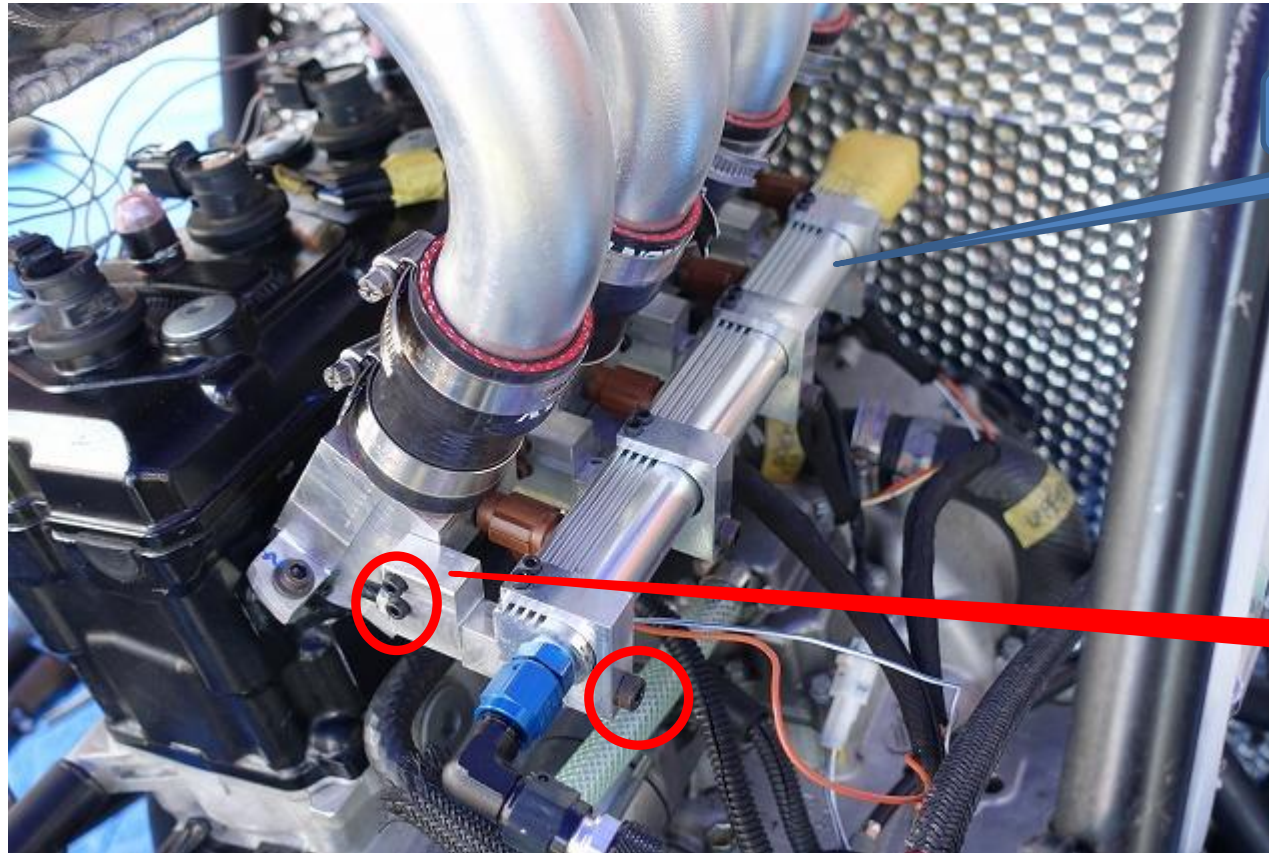
By spraying the developer in advance, even a slight leak can be detected.



# 1.Prevention of fires : 1.1-(2) Fuel rail

Even if the fuel rail is Ready-made, if the fastener is a self-made part, the critical fastener requirement (T.8.2) is applied as a "self-made" system.

※ Photo red frame

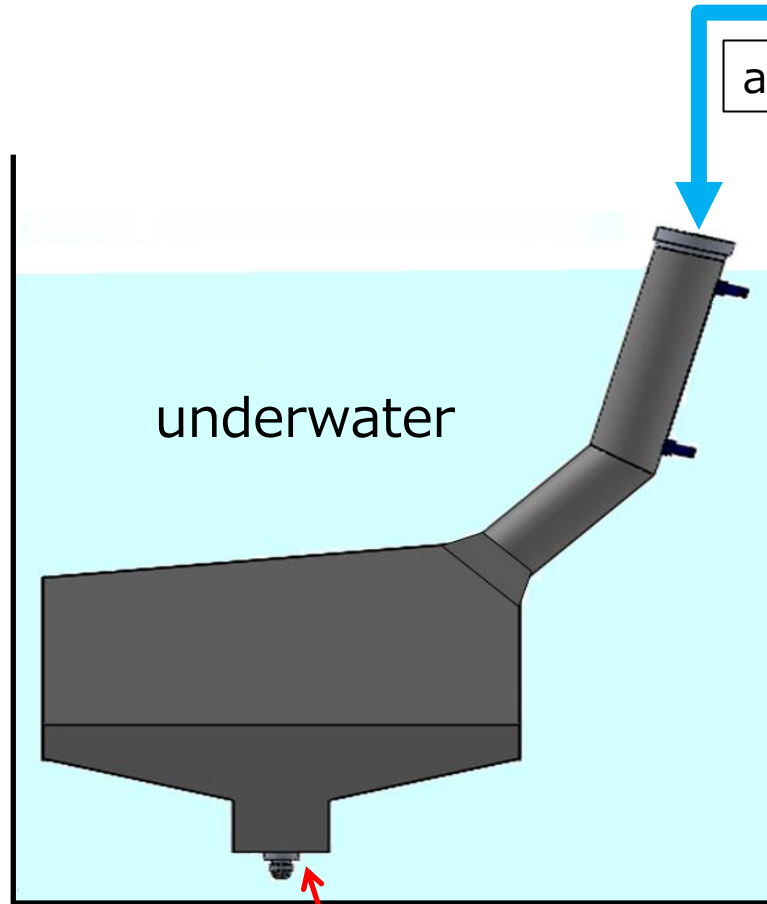


# 1.Prevention of fires : 1.1-(3) Fuel tank (airtightness confirmation)



Check the "tightness" in an appropriate way to prevent fuel leakage.

If you are not confident in the production, you can ask an outside company to produce it.



atmospheric pressure + 0.01kPa~0.02kPa



Air compressors



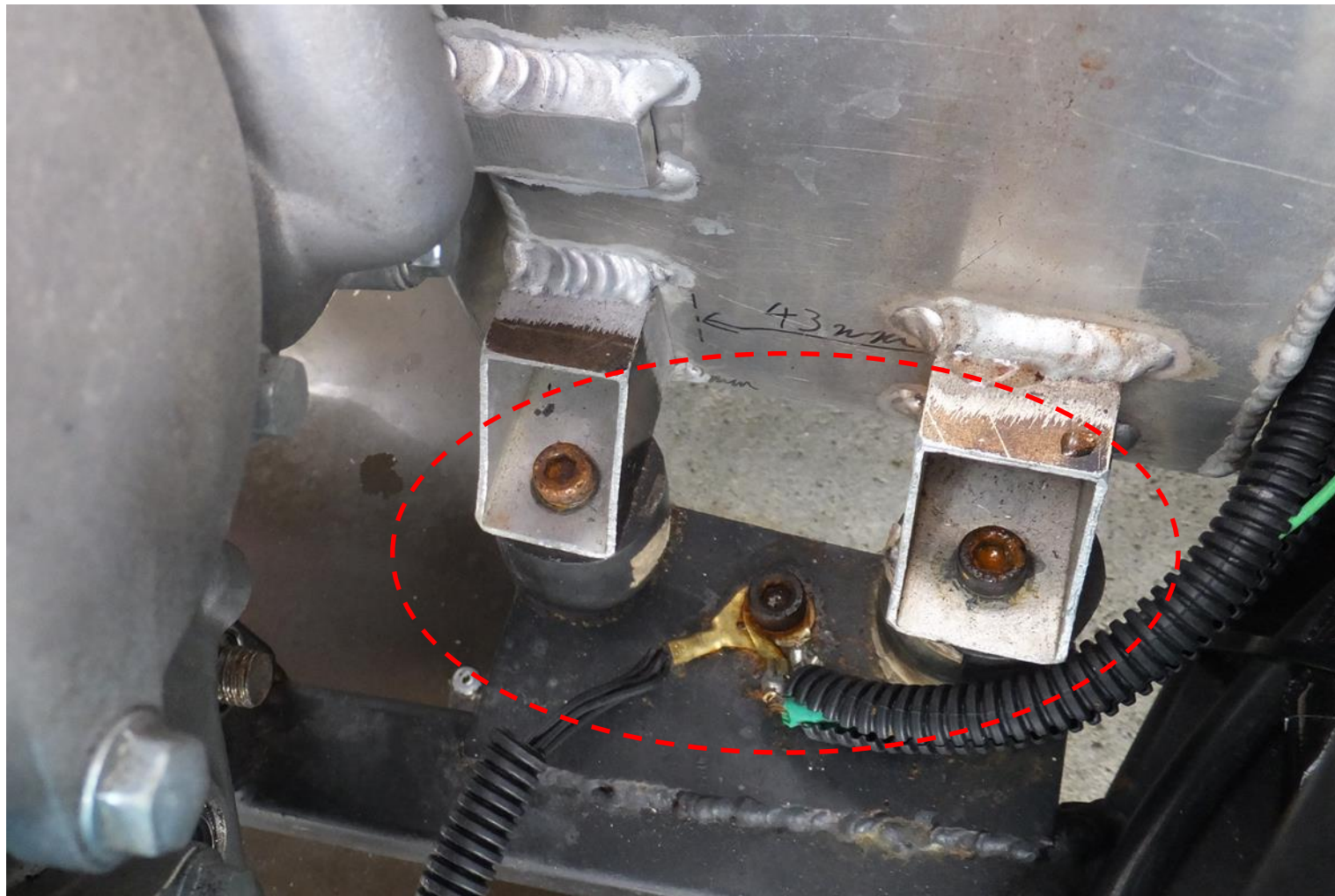
Reuse of drain washers is strictly prohibited (use new each time)

# 1.Prevention of fires : 1.1-(3) Fuel tank (fixed with frame)

Allow room (such as rubber bushings) for installation so that the tank does not receive the load (torsion) of the chassis (X-Y axis).

\* Take measures to reduce the axial torque of the mounting bolts without fail.

IC.5.3.1 If the bracket is vulnerable, it can crack







# 1.Prevention of fires : 1.1-(3) Fuel tank (distance to exhaust pipe)



All three of the following measures must be taken between the heat source and the panel where the driver may come into contact (T.1.6.3)

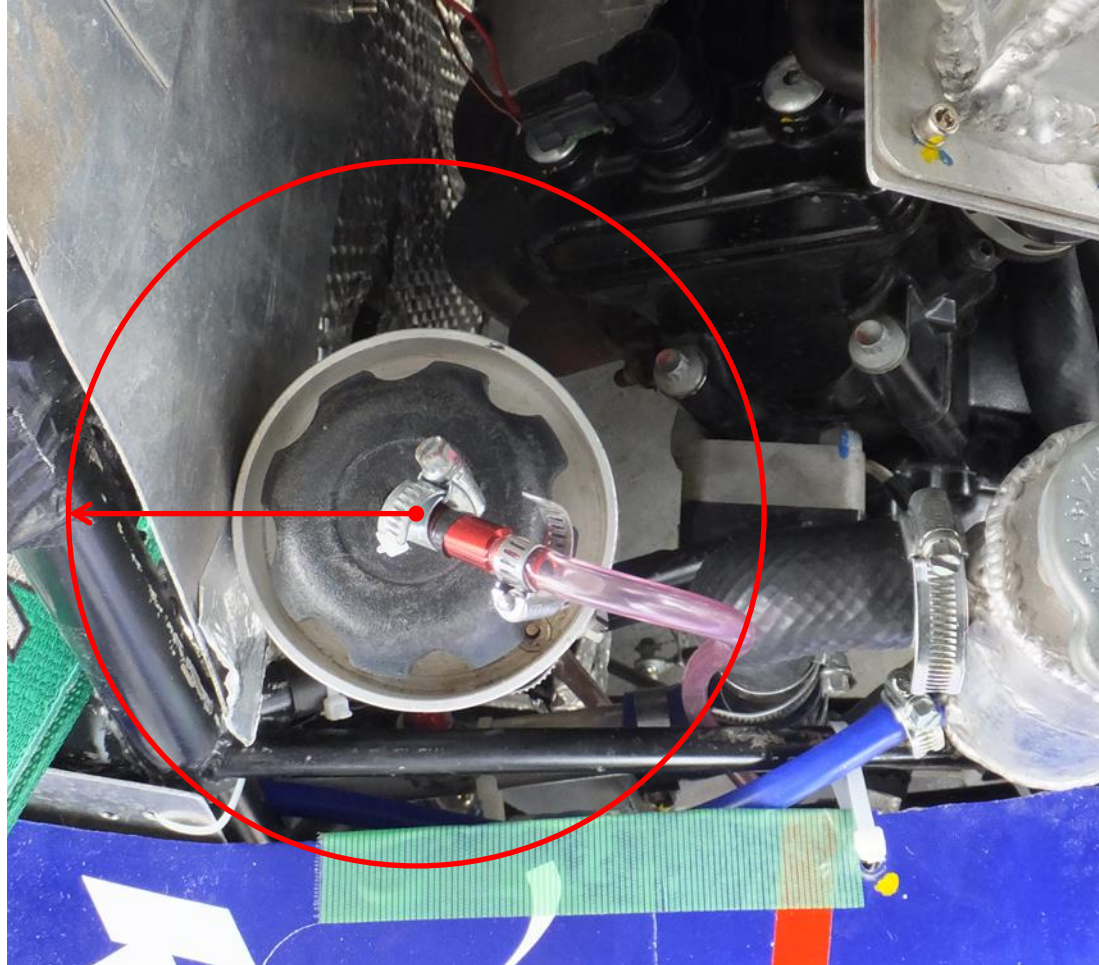
- a. Conduction measures: The heat source and the panel should not come into contact, or the insulation material of 8 mm or more should be sandwiched.
- b. Convection measures: An air gap of 25 mm or more should be provided.
- c. Radiation countermeasures: Attach a metal heat shield of 0.4 mm or more, or apply a heat reflecting sheet after



# 1.Prevention of fires : 1.1-(3) Fuel tank (refueling port position)

There are no ignition sources around the filling port to prevent ignition of spilled fuel when refueling. IC.5.2.1

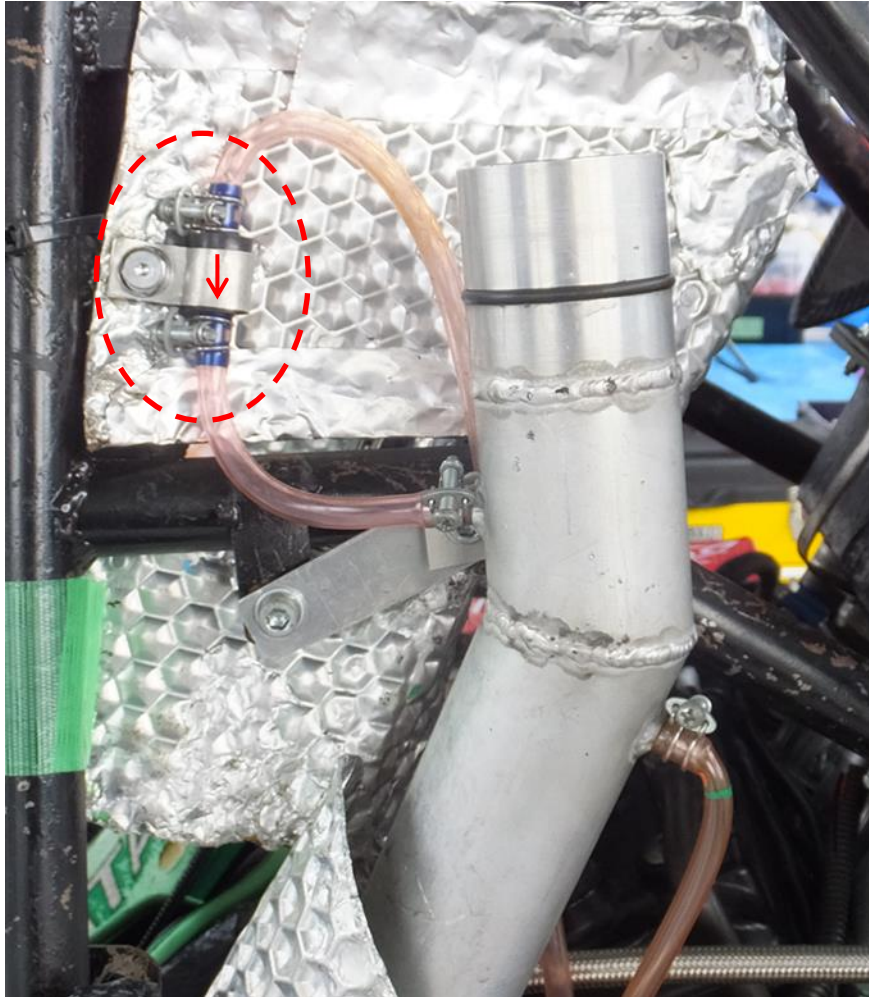
\* Generally within the range of the red circle





# 1.Prevention of fires :1.1-(3) Fuel tank (ventilation holes/tubes)

- How to use the vent (check valve)-
- Securely fixed vertically
- Pay attention to the orientation.
- Hang the tube to the bottom of the frame.



- (Site) Tube-
- Use products that have proven gasoline resistance.

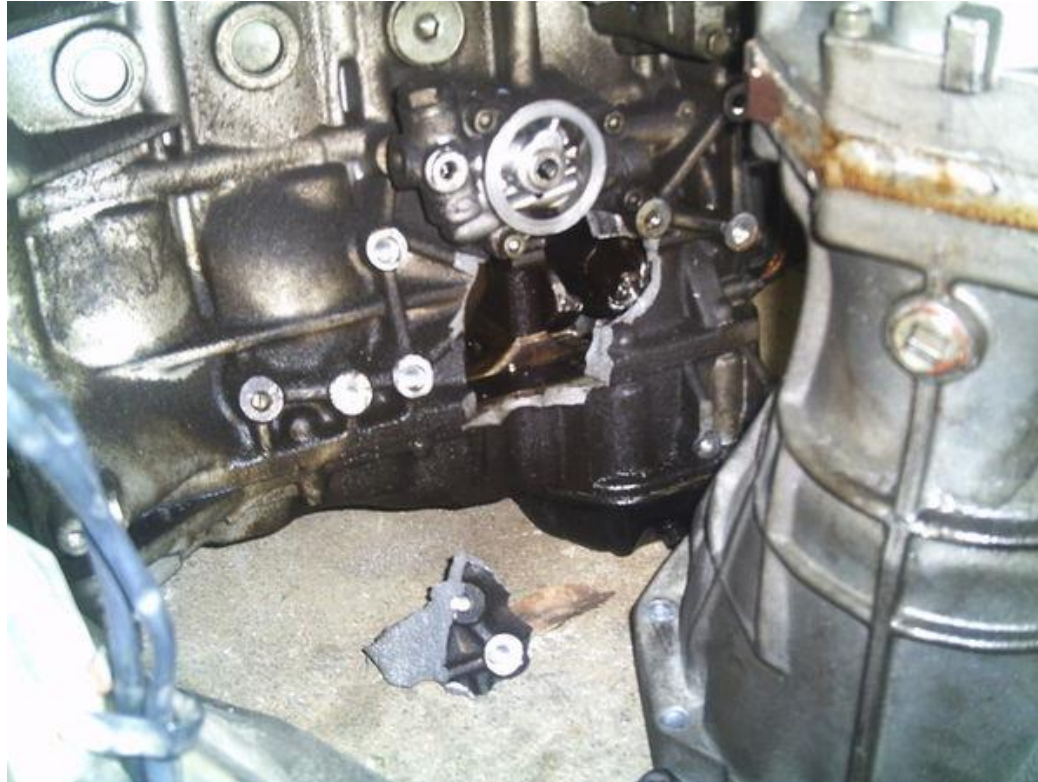


## <⚠ 使用上の注意 >

- 使用液体：軽油、灯油、重油、一般作動油  
(有機溶剤、ガソリン、食用油には使用できません。)
- 使用雰囲気温度：-20～60℃
- 常用使用圧力 (23℃)：1kgf/cm<sup>2</sup> (0.1MPa) 以下で



# 1.Prevention of fires : 1.2 Engine damage



The majority of fires at the Games were actually ignitions caused by large amounts of oil splatters caused by engine damage.

To break the block with the connecting rod sticking out the leg

(1) Burn-in from poor lubrication

(2) There are two main factors such as connecting rod coming off due to poor maintenance.

# 1.Prevention of fires : 1.2-(1) Poor lubrication



Oil pressure alarm lamp



Oil pressure sensor

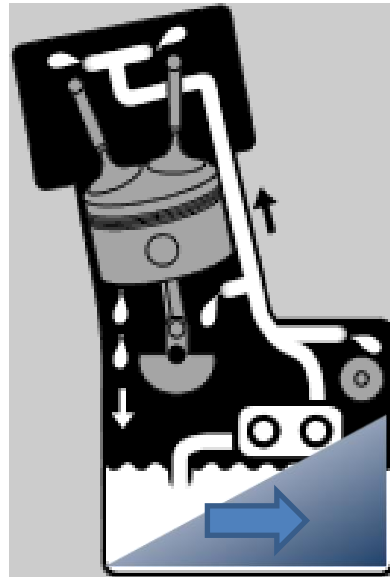
• As a countermeasure to poor lubrication, a means to confirm the decrease in oil pressure is provided.

• Before driving without relying on the oil pressure warning light, check not only the amount of oil but also the "condition".  
In past competitions, engine oil in an "emulsified" state, which seems to be contaminated with water, was found sometimes.

# 1.Prevention of fires : 1.2-(1) Poor lubrication

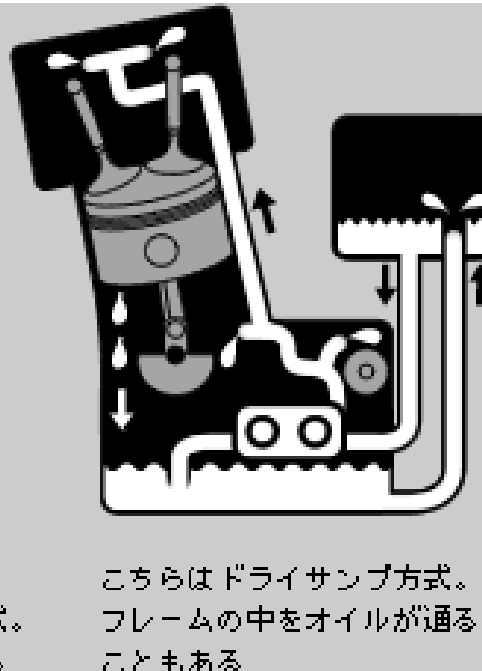
Care for transverse G  $\Rightarrow$  Example: Dry sumpification

Wet sump method



こちらがウェットサンプ方式。  
エンジンの中だけで循環する

Dry sump method



こちらはドライサンプ方式。  
フレームの中をオイルが通る  
こともある

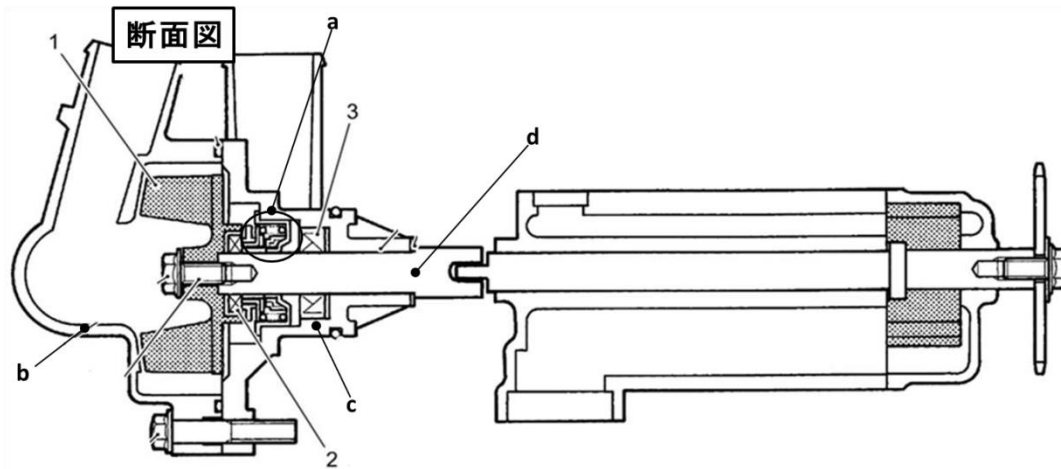
YAMAHA HP より

- When adopting a dry sump as a countermeasure against lateral G-forces, be aware of the following.
  - (1): Add a sufficient amount of engine oil. (At least 2~3 times the specified amount)
  - (2): Measures against air intake  $\Rightarrow$  foaming overflow  $\Rightarrow$  dripping on the road surface
  - (3): Oil temperature control (installation of oil cooler)
  - etc

# 1.Prevention of fires:1.2-(1) Poor lubrication (water contamination in oil)

There were many cases where oil that had been mixed with water and transformed into an "emulsified" state was ejected.

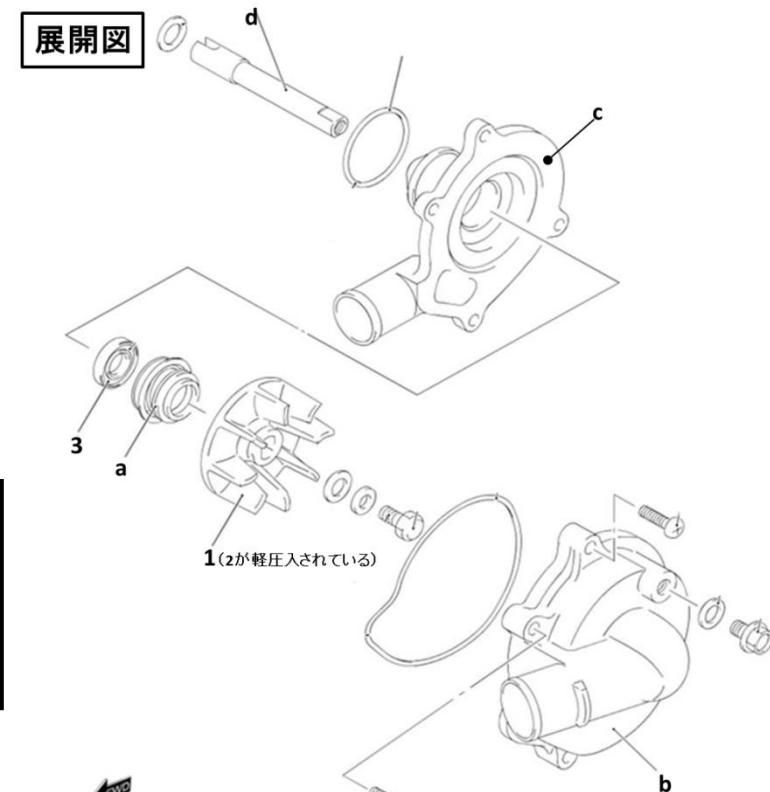
## (1) Water leakage from Water/Pump bearing



The engine is started  $\Rightarrow$  foreign matter in the water is generated  $\Rightarrow$   
Seal foreign matter bite  $\Rightarrow$  seal wear  $\Rightarrow$  water leakage  
\* Stickers should also be replaced regularly.

## (2) Water leakage due to overheating

Overheating  $\Rightarrow$  thermal distortion  $\Rightarrow$  water leakage



- 1. W/P impeller
- 2. Mechanical seal (floating sheet)
- a. Mechanical seal (sealing ring + spring + housing)
- 3. Oil seal
- b. W/P cover
- c. W/P body
- d. W/P shaft



# 1.Prevention of fires : 1.2-(2) Poor maintenance

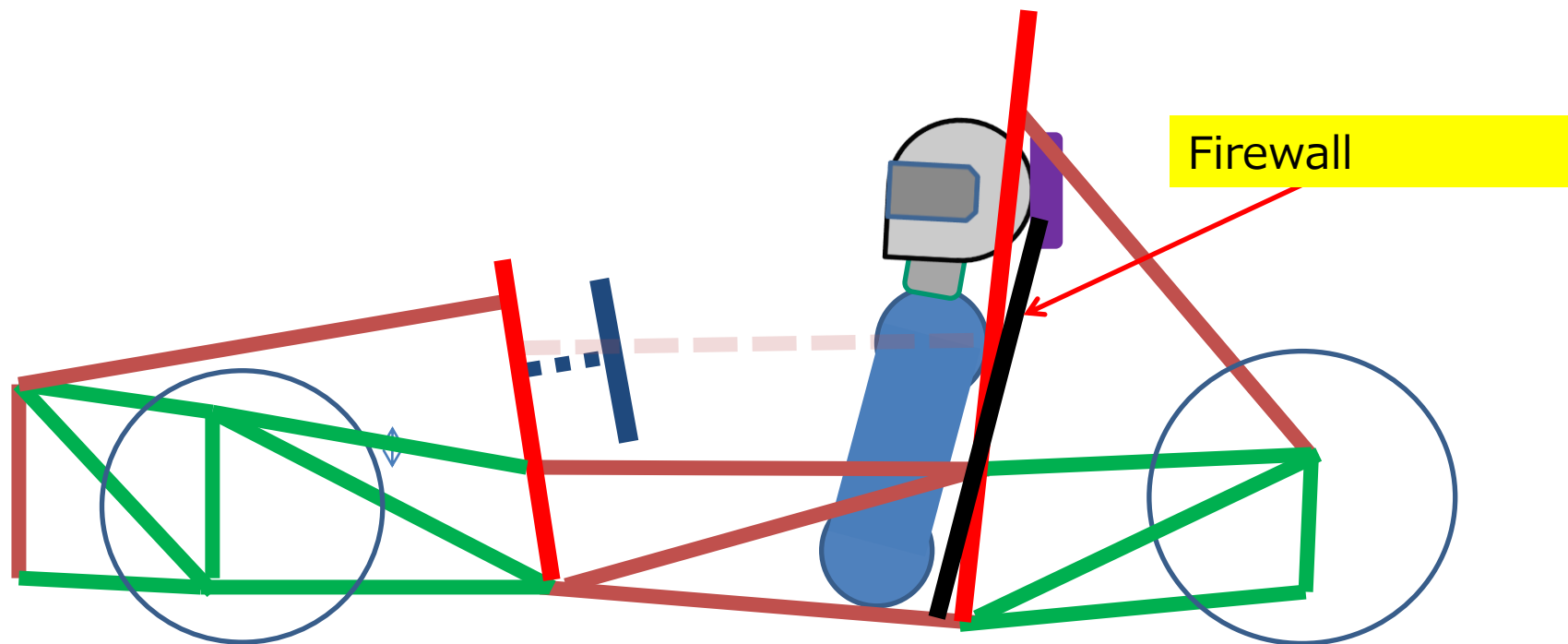
When the engine is disassembled and serviced  
Ensure reassembly is done in the correct procedure

- Forgot to tighten bolts
- Double check to ensure that there is no shortage of tightening torque

At the 2016 Games, the connecting rod foot has been stuck.  
It was fortunate that the  $\Rightarrow$  did not lead to a fire.



## 2.Driver Thermal Protection: 2.1 Firewall



Protect the driver from "any heat source". (T.1.8.1)

- \* Constructed with materials according to the temperature of the heat source.

Responding to high temperatures such as flames

Plate thickness: T0.7mm for aluminum, T0.5mm or more for iron plate is recommended.

- \* In the case of Fukai Manufacturing "enbrella",

- Multilayer product, single layer product (1mm): Confirmed compliance with fire resistance standards, can be used unconditionally.

- Single layer products (0.5mm, 0.3mm): Require fire resistance certification by the team

Firewalls must be made without gaps

## 2.Driver Thermal Protection: 2.1 Firewall

Production example (without gaps)



- Make a firewall without gaps. (The harness is threaded using a grommet)

## 3.Other precautions : 3.1 Shakedown

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Carefully follow these steps:

- (1) Add fuel and check for leaks from the tank & fuel line!
- (2) Turn the engine stationary to prevent leakage of fuel, oil and water  
Check again and again!
- (3) Gradually increase the speed and test run!
- (4) Acceleration, turning, stopping, suspension & brake confirmation! !!
- (5) Check for leak even after driving

※Shakedown proof must be submitted as soon as possible



- Follow the main points and build a safe vehicle.
- Please complete the vehicle as soon as possible, check it carefully, and participate in the competition.
- Impossible participation in the tournament will induce an accident and cause trouble to the tournament itself and other teams.

We hope that you will pass the technical vehicle inspection in one go and fully enjoy the dynamic competition.

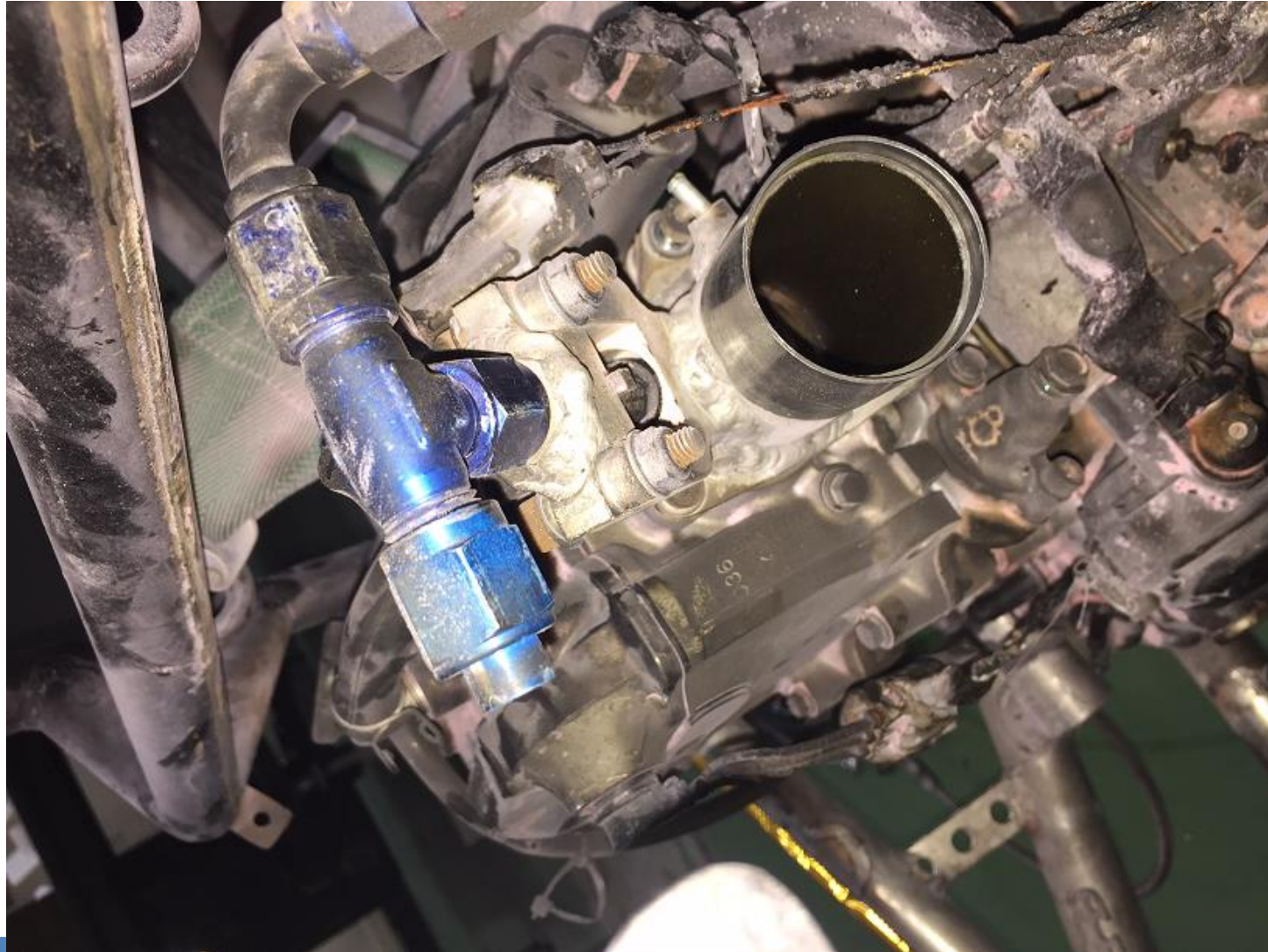
The following are references

# Fire case (team with top prize experience)

Fire caused by fuel leakage from the fuel line (joint).

The flames reached the driver, but the racing suit protected him and his skin turned a little red.

The direct cause is presumed to be poor tightening of the joint.



Note: Drivers are protected by the following requirements: (Firewall)

T.1.6 Sufficient insulation must be used to prevent the driver from coming into contact with metals or other components that may have a surface temperature of 60 °C or higher when the driver is seated in a normal riding position.

The insulation may be outside the cockpit or coalesced into a driver seat or firewall.

The design allows for heat sources like exhaust pipes or coolant hoses/pipes and dry as in seats and floors

Evidence must be shown of dealing with three types of heat conduction with the panels with which the bars come into contact: thermal conductivity, convection and heat dissipation.

a. Heat transfer isolation by:

i.. No direct contact between the heat source and the panel

ii.. Heat-resistant heat transfer isolation material with a thickness of at least 8 mm between the heat source and the panel

b. Heat conduction isolation by providing a minimum air gap of 25 mm between the heat source and the panel

c. Heat dissipation isolation by:

i.. Metal heat shielding plate with a thickness of 0.4 mm or more

II.. Reflective metal plate or reflective tape incorporated in aii..



END