



# **TECHNICAL AGREEMENT FOR BPS-TJ220 TURBOJET ENGINE**

## 1. Overview

This document specifies the work content and technical requirements for the procurement of the BPS-TJ220 turbojet engine.

## 2. Referenced Documents

- GJB241A-2010 General Specification for Aircraft Turbofan and Turbojet Engines
- HB5800-2021 General Tolerances

## 3. Technical Requirements

### 3.1. Engine Technical Requirements

#### 3.1.1. General Technical Data

##### a) Engine Outline Dimensions

- Maximum Diameter: Ø320mm (excluding external screws and accessories)
- Maximum Length: 645mm
- Inlet Inner Diameter: Ø172mm

##### b) Engine Weight

- Engine Dry Weight: 29kg (excluding ECU).

##### c) Engine Life Limits

- BPS-TJ220 Engine First Overhaul Life: 10 hours.
- Total Life: 30 hours or 60 starts.
- Storage Life: 3 years.

#### 3.1.2. Main Performance Data

##### a) Engine Standard Atmospheric Conditions, Sea Level, Static Parameters

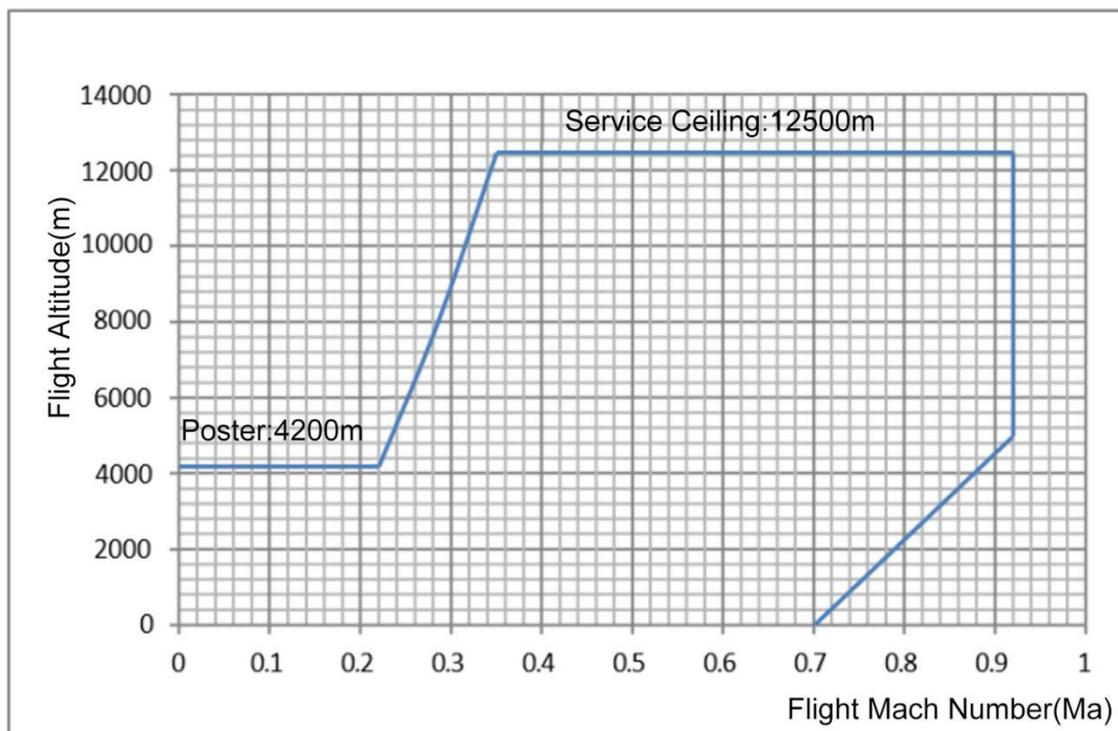
**Table 1 Engine Performance Parameters**

No.	Parameter	Value
1	Maximum Thrust (daN)	220
2	Minimum Thrust (daN)	18
3	Specific Fuel Consumption (kg/daN.h)	1.35

No.	Parameter	Value
4	Maximum Speed (r/min)	46000
5	Minimum Speed (r/min)	20000
6	Maximum Exhaust Gas Temperature (°C)	<750

### b) Operating Envelope

- Maximum Flight Altitude: 12500m;
- Maximum Flight Speed: 0.92Ma;
- Minimum Operating Temperature: -45°C;
- Minimum Starting Temperature: -30°C;
- Maximum Operating Temperature: +60°C.



**Figure 1 Engine Operating Envelope**

### c) Limitations

- 1) Maximum Allowable Physical Speed: 46000 r/min;
- 2) Maximum Allowable Single-Point Exhaust Gas Temperature: 750°C;

### 3) Continuous Operation Time Limits:

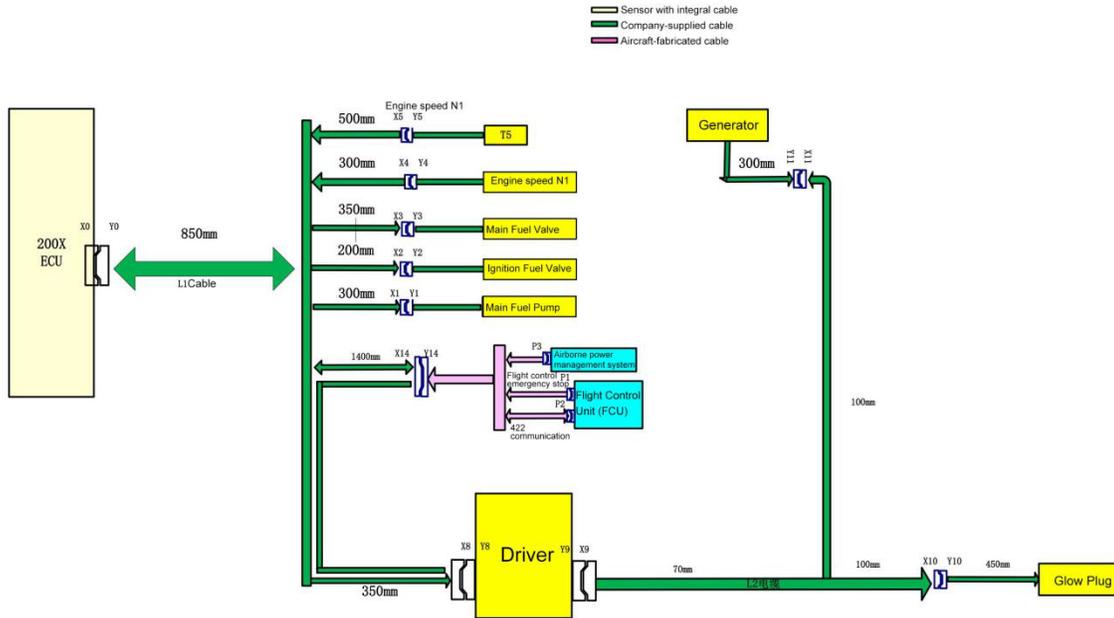
- \* With good ventilation, can operate continuously below 43000 r/min.
- \* Between 43000 r/min and 46000 r/min, within a cumulative 20 minutes, continuous operation time is 10 minutes. After continuous use, must reduce speed to below 43000 r/min for 2 minutes before reuse.
- \* Between 45000 r/min and 46000 r/min, within a cumulative 20 minutes, continuous operation time is 5 minutes. After continuous use, must reduce speed to below 43000 r/min for 2 minutes before reuse.
- \* Single flight duration: 15 minutes.

### 3.1.3. Fuel System

- a) **Fuel:** RP-3 aviation kerosene.
- b) **Lubrication:** Aeroshell 500 lubricating oil. Mix RP-3 aviation kerosene and Aeroshell 500 lubricating oil uniformly at a mass ratio of 19:1 for use.
- c) **Main Fuel Pump**
  - Pump Type: Gear pump;
  - Inlet Pressure Requirement: 50~100kPa (gauge pressure);
  - An oil filter must be installed before the pump; recommended filter rating is 40-80 microns.
- d) **Fuel Line Connection Thread Specifications**
  - i. Main fuel pump inlet line connection: 74° cone hard tube connection form, using hard tube specification  $\phi 121$ , *outer sleeve nut internal thread specification M181.5*. The flat pipe nozzle and outer sleeve nut are supplied with the engine.
  - ii. Bleed air line connection: 74° cone hard tube connection form, using hard tube specification  $\phi 41$ , *outer sleeve nut internal thread specification M101*. The flat pipe nozzle and outer sleeve nut are supplied with the engine.

### 3.1.4. Electrical System

#### 3.1.4.1. Electrical Connection Diagram



**Figure 2 Electrical System Interconnection Diagram**

#### 3.1.4.2. Aircraft-Engine Interface Cable Description

There is only one pair of X14-Y14 connector plug between the aircraft and the engine; the rest are internal engine cables. Pin definitions are shown in the table below.

**Table 2 Pin Definitions**

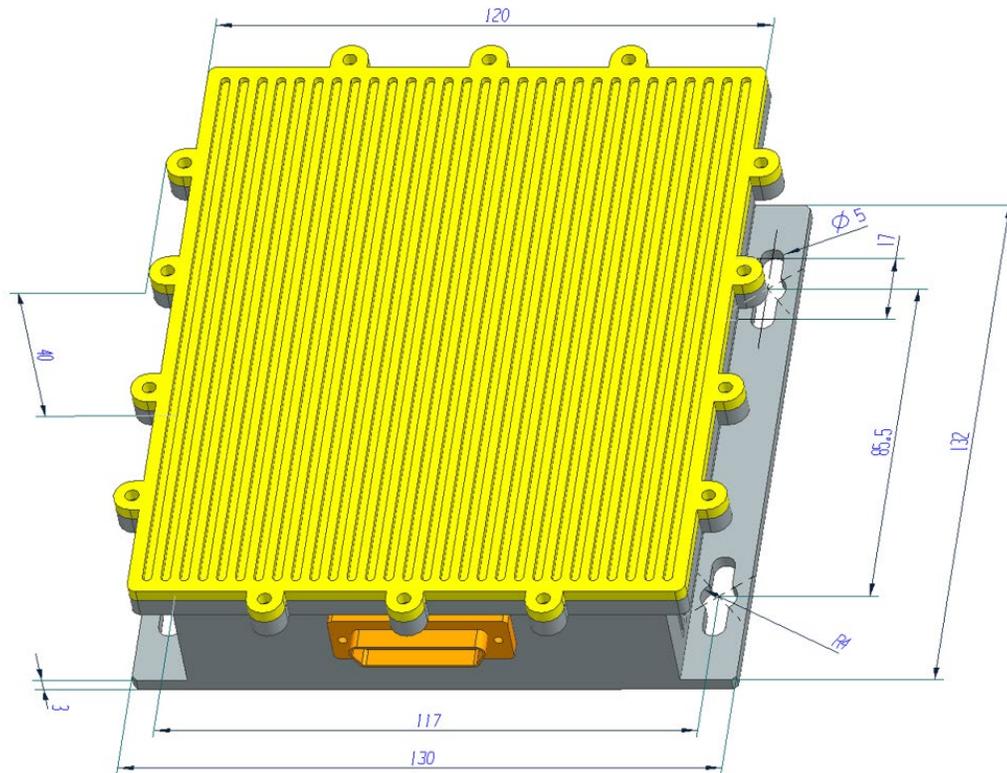
Pin No.	Signal Name	Source	Destination	Electrical Characteristics	Remarks
2	28V Input+	Aircraft Power	Engine ECU	24V~32V, 10A	
20	28V Input-	Aircraft Power	Engine ECU	24V~32V, 10A	
21	28V Input+	Aircraft Power	Engine Actuator	24V~32V 40A	
22	28V Input+	Aircraft	Engine Actuator		

Pin No.	Signal Name	Source	Destination	Electrical Characteristics	Remarks
		Power			
1	28V Input-	Aircraft Power	Engine Actuator	24V~32V	
3	28V Input-	Aircraft Power	Engine Actuator	40A	
9	RXD+	Aircraft End	Engine ECU	RS422 Signal	Twisted Pair Shielded
10	RXD- (or CAN_H)	Aircraft End	Engine ECU		
11	TXD+	Engine ECU	Flight Control Computer		Twisted Pair Shielded
12	TXD- (or CAN_L)	Engine ECU	Flight Control Computer		
13	GND A2				

### 3.1.5. Engine Electronic Controller (ECU)

#### 3.1.5.1 General Requirements

The Engine Electronic Controller (hereinafter referred to as ECU) is a precision electronic product using integrated circuit technology. Rated input voltage DC28V, maximum power consumption not exceeding 300W. Its outline 3D model is shown in the figure below:



**Figure 3 ECU 3D Model Dimension Diagram**

### ***3.1.5.2 Engine-Aircraft Communication Protocol***

The BPS-TJ220 engine controller communicates with the aircraft flight control computer using an RS422 interface. Baud rate is 115200bps. Each byte consists of: 1 start bit, 8 data bits, odd parity bit, 1 stop bit. Data is transmitted in frames. Each frame data format: Frame Header (2 bytes) + Data Block + Checksum (1 byte).

#### **(1) Data Transmission Requirements from Flight Control Computer to Engine Controller**

**Table 3 Flight Control Computer to ECU Command Frame Format**

Byte	Data Bits	Name	Data Word Meaning
1	Byte 1	0XF0	Header 1
2	Byte 2	0X0F	Header 2
3	Byte 3	Cmd	Operational State Control Command (See Table 4)
4	Byte 4	Cmd Repeat 1	Same as Cmd
5	Byte 5	Given Physical Speed (0-46000)	Given Speed High 8 bits (unsigned integer, unit: rpm)
6	Byte 6		Given Speed Low 8 bits (unsigned integer, unit: rpm)
7	Byte 7	Acceleration Gear	01 Normal Gear (use normal fuel supply parameters) 02 Acceleration Gear (increase acceleration rate), use of this gear not recommended
8	Byte 8	Atmospheric Temperature TIs	Aircraft Atmospheric Static Temperature -200, unit K
9	Byte 9	Airspeed Data	High 8 bits (unsigned integer, unit km/h)
10	Byte 10	Vair	Low 8 bits (unsigned integer, unit: km/h)
11	Byte 11	Pressure Altitude H	High 8 bits (unsigned integer, unit: meters)
12	Byte 12		Low 8 bits (unsigned integer, unit: meters)
13	Byte 13	Given K Value	Fill with OOH here
14	Byte 14		Fill with OOH here
15	Byte 15	0x2A (*)	Fill with *, indicates system formal operation control mode
16	Byte 16	Checksum	Sum Check
<b>Remarks</b>	1. Checksum is "Sum Check", i.e., Byte3+Byte4+...+Byte15 equals the		

Byte	Data Bits	Name	Data Word Meaning
			Checksum byte; 2. Transmission frequency $\leq 25\text{Hz}$ ; 3. Delimiter '*' (i.e., 0x2A) indicates system formal operation control mode, '#' (i.e., 0x23) indicates ground test mode. Flight control uses the system formal operation control mode. 4. Atmospheric temperature refers to the aircraft atmospheric static temperature. 5. Airspeed refers to true airspeed. 6. After successful engine start, the ECU internally limits the minimum speed: For the 190/220 engine, below 4000m is 20000rpm, 4000m~6000m is 28000rpm, 6000m~10000m is 33000rpm, above 10000m is 38000rpm.

**Table 4 Cmd Operational State Control Command Definitions**

Cmd Value	Meaning	Detailed Description
0x00	Null Command	Null Command
0x13	Cold Cranking	Start motor on. Ends when run time reaches 10s or receives "Stop" or "Emergency Stop" command, start motor off. Note: This command function can also be implemented by the ground start box "Cold Crank" button. Button pressed -> start motor on; button released -> start motor off.
0x43	Stop	Engine speed first decreases to ground idle or fuel flow reaches minimum limit, maintain for 2s (TBD), then cut off fuel to stop.
0x73	Emergency Stop	Engine responds to this command in any state. Immediately closes fuel, oil valves, etc., finally causing the engine to stop.

<b>Cmd Value</b>	<b>Meaning</b>	<b>Detailed Description</b>
0x15	Ground Start	Engine automatically executes the ignition start process until reaching idle speed and enters "steady state". Note: This command function can also be implemented by the ground start box "Start" button. Press and hold the "Start" button for more than 2s to enter the automatic start process.
0x45	Speed Setting	The given speed bytes (Byte5 and Byte6) are valid at this time. The engine automatically adjusts to the given speed. Note: This command can only be used after the engine has started to idle "steady state", otherwise it will not respond.
0xd5	Manual Control Mode	After the ECU receives the "Manual Control Mode" command, it switches to manual debugging mode, exiting PID closed-loop control mode. After switching to manual mode, it cannot reversibly switch back to PID closed-loop control mode. When the system is working in the "formal operation control mode", entering manual mode controls the K value.
0x19	Main Fuel Pump Check	Turns on the main fuel valve and main fuel pump to check if the fuel pump works normally. This command can also be used to prime the fuel lines before engine start. When sending this command, the speed data in Byte5 and Byte6 needs to be filled, usually set given speed=20000. The ECU stops the fuel pump check work upon receiving the "Stop" or "Emergency Stop" command.
0x89	Igniter Check	Turns on the igniter control relay to check if the igniter works normally. The ECU stops the igniter check work upon receiving the "Stop" or "Emergency Stop" command.
0xb9	Start Control 1 Check	Used to check if various accessories are working normally. When the ECU receives the check command, the corresponding IO port outputs high
0xd9	Start Control	

<b>Cmd Value</b>	<b>Meaning</b>	<b>Detailed Description</b>
	2 Check	level, opening the corresponding control valve. Upon receiving the "Stop" or "Emergency Stop" command, the corresponding IO port outputs low level, closing the corresponding control valve.
0x1a	Ignition Fuel Valve Check	
0x8a	Main Fuel Valve Check	
<b>Remarks</b>	<p>1. Engine manual operation mode: This mode is the engine open-loop control mode, performing open-loop control based on the target speed. The actual speed may not be the same as the target speed. This mode is entered automatically when the engine speed sensor fails, or can be entered by sending the "Manual Control Mode" command from the flight control computer. After entering manual operation mode, PID mode is exited and cannot be restored to PID mode.</p> <p>2. All commands containing "Check" are only responded to when the engine is in the "Stopped" or "Check" state, otherwise they are invalid.</p>	

## **(2) Data Transmission Requirements from Engine Controller to Flight Control Computer**

**Table 5 ECU to Flight Control Computer Command Frame Format**

Byte	Data Bits	Name	Data Word Meaning
1	Byte 1	0XF0	Header 1
2	Byte 2	0x0F	Header 2
3	Byte 3	Engine Physical Speed	Physical Speed, High 8 bits (unsigned integer, unit rpm)
4	Byte 4		Physical Speed, Low 8 bits (unsigned integer, unit rpm)
5	Byte 5	Exhaust Gas Temperature T5	High 8 bits (unsigned integer, unit K, T5*10)
6	Byte 6		Low 8 bits (unsigned integer, unit K, T5*10)
7	Byte 7	Fuel K Value	Current K Value High 8 bits (unsigned integer, 0~7500)
8	Byte 8		Current K Value Low 8 bits (unsigned integer, 0~7500)
9	Byte 9	Desired Physical Speed	Desired Speed, High 8 bits (unsigned integer, unit rpm)
10	Byte 10		Desired Speed, Low 8 bits (unsigned integer, unit rpm)
11	Byte 11	Returned Desired Speed	Desired Speed sent by Flight Control, High 8 bits (unsigned integer, unit rpm)
12	Byte 12		Desired Speed sent by Flight Control, Low 8 bits (unsigned integer, unit rpm)
13	Byte 13	Returned Acceleration Gear	Gear sent by Flight Control, 01 Normal Gear, 02 Acceleration Gear (unsigned integer)
14	Byte 14	Returned Atmospheric	Aircraft Atmospheric Static Temperature -200 sent by Flight

Byte	Data Bits	Name	Data Word Meaning
		Temperature	Control, unit K
15	Byte 15	Returned Airspeed	High 8 bits (unsigned integer, unit: km/h)
16	Byte 16		Low 8 bits (unsigned integer, unit: km/h)
17	Byte 17	Returned Altitude	High 8 bits (unsigned integer, unit: meters)
18	Byte 18		Low 8 bits (unsigned integer, unit: meters)
19	Byte 19	Inlet Total Temperature Tlt	Tlt-200, unit K, Tlt range 213~453K
20	Byte 20		
21	Byte 21	Power Supply Voltage	Low 8 bits (unsigned integer, unit 10mV)
22	Byte 22		Low 8 bits (unsigned integer, unit 10mV)
23	Byte 23	Engine Backup Speed	Low 8 bits (unsigned integer, unit rpm)
24	Byte 24		Low 8 bits (unsigned integer, unit rpm)
25	Byte 25	(Backup Parameter 1)	Fill with 0x0
26	Byte 26		Fill with 0x0
27	Byte 27	(Backup Parameter 2)	Fill with 0x0
28	Byte 28		Fill with 0x0
29	Byte 29	Switching quantity status IOState	Low 8 bits
30	Byte 30		Table 8, Low 8 bits
31	Byte 31	System control status word SysState	Table 7, High 8 Bits
32	Byte 32		Low 8 bits

Byte	Data Bits	Name	Data Word Meaning
33	Byte 33	Fault status word	Table 8, High 8 Bits
34	Byte 34		Low 8 bits
35	Byte35	intrinsic parameter	
36	Byte36		
37	Byte37	Return command	Instruction returned (see Table 3-1)
38	Byte38	check word	sum verification
<b>Remarks</b>	<p>1. Transmission frequency is 25Hz.</p> <p>2. Checksum is "Sum Check", i.e., Byte3+Byte4+...+Byte33 equals the Checksum byte.</p> <p>3.The parameters "Engine Physical Speed", "Exhaust Gas Temperature", and "Engine State" must be displayed on the ground station. "Current K Value" and "Power Supply Voltage" are preferably displayed on the ground station. Others may not be displayed.</p> <p>4.The flight control computer saves all parameter information sent by the ECU.</p>		

**Table 6 Digital I/O Status IOState**

Status Bits	Meaning
D0-D11	Output Digital Signals
D12-D15	Input Digital Signals

Status Bit	Signal	Direction	Description
D0	Igniter Fire	DO	1: High level output, turn on external device 0: Low-level output, turn off external devices
D1	Ignition Fuel Valve FuelFire	DO	
D2	(Spare)	DO	
D3	(Spare)	DO	
D4	(Spare)	DO	
D5	Start Control 1 StartMotor1	DO	
D6	Start Control 2 StartMotor2	DO	
D7	Main Fuel Valve FuelMain	DO	
D8	(Spare)	DO	
D9	(Spare)	DO	
D10	(Spare)	DO	
D11	(Spare)	DO	
D12	Start Switch	DI	1: Turn on the switch 0: Turn off the switch
D13	(Spare)	DI	
D14	Flight Control Emergency Stop Switch D128_Estop	DI	1: 28V high level input 0: Low level input
D15	(Spare)	DI	
Remark	May not be displayed on the ground station.		

**Table 7 System Control Status Word SysState**

<b>Status Bits</b>	<b>Meaning</b>
D0-D3	Engine Running State RunState
D4-D7	ECU System Running Mode ECUMode
D8-D15	Warning Status Word Warn

**RunState: Engine Running State**

D3:D0	Explanation
0x00	Stationary
0x01	Ground inspection
0x02	Cold run
0x03	(Spare)
0x04	Stop
0x05	Ground up
0x06	(Spare)
0x07	Manual
0x08	Safety
0x09	Steady state
0x0a	Deceleration
0x0b	Acceleration

0x0c	(Spare)
0x0d	(Spare)
0x0e	(Spare)
0x0f	(Spare)

### ECUMode: ECU System Running Mode

Status Bit	Signal	Description
D4	Control Running Mode	1: Formal Operation 0: Ground Debugging
D5	N Main Sensor Channel	1: N2 Sensor 0: N1 Sensor
D6	(Spare)	/
D7	(Spare)	/

### Warn: Engine Warning Status Word

D8	N Overspeed	1: Alarm 0: Normal
D9	T5 Overtemperature	1: Alarm 0: Normal
D10	(Spare)	1: Alarm 0: Normal
D11	(Spare)	1: Alarm 0: Normal
D12	Ignition Failure	1: Failure 0: Normal
D13	Start Failure	1: Failure 0: Normal
D14	(Spare)	/
D15	(Spare)	/
<b>Remarks:</b>		

**Table 8 Fault Status Word Fault**

<b>Status Bit</b>	<b>Signal</b>
D0	CPU
D1	Power Supply
D2	N1 Speed Sensor
D3	N2 Speed Sensor
D4	T5 Exhaust Temperature Sensor
D5	(Spare)
D6	(Spare)
D7	(Spare)
D8	(Spare)
D9	RS422
D10	Main Fuel Valve Control Output
D11	Main Fuel Pump Control Output
D12	(Spare)
D13	(Spare)
D14	(Spare)
D15	(Spare)
<b>Remark</b>	0 indicates sensor signal normal, 1 indicates signal fault. May not be displayed on the ground station.

### (3) Flight Control Computer Operational Control Steps for the Engine

1. Before engine start, flight control sends the "Igniter Check" command to check the igniter. Send the "Stop" or "Emergency Stop" command to stop the check.
2. Before engine start, flight control sends the "Ignition Fuel Valve Check" command to check the ignition fuel pump. Send the "Stop" or "Emergency Stop" command to stop the check.
3. Flight control sends the "Main Fuel Pump Check" command to check the fuel pump, with given speed  $v=20000$ , simultaneously priming the fuel lines. Send the "Stop" or "Emergency Stop" command to stop the fuel pump check and priming. This priming process typically lasts 2~3s.
4. Before engine start, flight control sends the "Cold Cranking" command to check the start motor. The motor begins to rotate, maximum speed generally around 3500-4000rpm. Send the "Stop" or "Emergency Stop" command to stop the check. The engine speed gradually decreases to 0. At this point, observe the turbine rotor rotation direction from the engine exhaust outlet, confirm it is clockwise, indicating normal motor operation.
5. Press and hold the "Start" button on the ground start box for more than 2 seconds, or after the flight control sends the "Start Command", the engine control responds to the start signal and enters the engine start program until reaching idle steady state. The engine start is successful. If a button is not needed, the "Start" button need not be set up on the ground station.
6. After successful start, flight control sends the "Speed Setting" command. The engine will perform automatic PID adjustment according to the given speed.
7. Flight control sends the "Stop" or "Emergency Stop" command to put the engine into the stop state. Note the following: The Emergency Stop command can be used before start checks and after start when the speed is below 32000rpm. If the speed is above 32000rpm, do not use this command arbitrarily except in emergencies. Normally, only use the Stop command.

### **3.1.6. Engine Installation Requirements**

#### **3.1.6.1 Engine Bay**

The engine bay must have sufficient air for ventilation and cooling to reduce the heat transferred from engine hot parts to the aircraft via radiation and conduction. The structural form of each engine mounting point should allow the engine to expand freely along the axial and radial directions during operation.

#### **3.1.6.2 Engine and Inlet Installation**

The inlet mounting flange inner diameter is  $\phi 172\text{mm}$ . The flange holes are 5.5mm through holes, evenly distributed with 8 holes. See the 3D full engine model for the front casing accessory layout.

The connection between the engine and the inlet must meet the following requirements: (1) Ensure the seal between the engine and the inlet is airtight. (2) Ensure a smooth transition between the engine and the inlet internal flow path surfaces. (3) The engine intake end face must not bear force from any direction. (4) The engine intake end face displaces forward during operation. The elongation from the main mounting surface to the intake end face is not more than 0.5mm. Installation must ensure the casing has freedom for forward displacement. (5) There must be no loose foreign objects inside the inlet.

#### **3.1.6.3 Engine Main Mount and Auxiliary Mount**

The engine main mount consists of 4 threaded holes (left-right symmetrical), thread specification M10 $\times$ 1, thread depth 8mm. The engine auxiliary mount is a  $\phi 9\text{mm}$  round hole, thickness 8mm.

Precautions:

- (1) During handling, avoid applying force to the accessory part in front of the engine mounting surface and avoid applying force to the nozzle section.
- (2) The engine nozzle displaces rearward during operation. The elongation from the main mounting surface to the nozzle is not more than 5mm. Installation must ensure free clearance, and axial expansion clearance must be ensured at the auxiliary mount.

### **3.2. Completeness Requirements**

The components of each power plant set are as shown in the table below.

**Table 9 Power Plant Components List per Set**

<b>No.</b>	<b>Name</b>	<b>Model</b>	<b>Form</b>	<b>Quantity</b>	<b>Remarks</b>
1	Turbojet Engine	BPS-TJ220	Physical Object	1 unit	
2	ECU		Physical Object	1 unit	
3	Cable		Physical Object	1 piece	
4	Outer Sleeve Nut		Physical Object	1 piece	
5	Outer Sleeve Nut		Physical Object	1 piece	
6	Flat Pipe Nozzle		Physical Object	1 piece	
7	Flat Pipe Nozzle		Physical Object	1 piece	
8	Electrical Connector (Aircraft Interface)		Physical Object	1 piece	Y14

### **3.3. Interchangeability Requirements**

The engine and its accessory equipment shall be interchangeable.

### **3.4. Appearance Quality Requirements**

The product appearance shall be intact, without bumps or paint loss.

### **3.5. Packaging Requirements**

The product shall be provided in a packaging case. Upon delivery, the product shall be placed inside the packaging case, securely fastened, with cushioning foam inside.

### **3.6. Usage Requirements**

Party A shall record the engine operating time and usage according to the engine life limit requirements, providing a basis for subsequent engine overhaul or inspection.

## **4. Inspection and Delivery**

### **4.1. Inspection Rules**

Party A conducts on-site inspection, checking product appearance, completeness, and factory inspection records.

### **4.2. Delivery**

Delivery content, form, and quantity are as shown in Table 10.

**Table 10 Delivery List**

No.	Name	Form	Quantity	Remarks
1	BPS-TJ220 Turbojet Engine	Physical Object	As per contract	
2	Engine Inspection Record Sheet Inspection Record Sheet	Document	Provided in conjunction with the engine	verification of conformity
3	Shipping List	Document	Provided with engine	