How to Evaluate Applications with Increased Peripheral Equipment Loading

Some applications may require using peripheral equipment (upper arm payload) that is beyond the robot's specifications. It is recommended to start with a MotoSize analysis to confirm if the peripheral equipment is out of specification. MotoSize uses the specification values from the robot's manual (typically in chapter 7 "System Application"), which assumes that the wrist is at maximum payload. However, when the wrist is below maximum payload, the peripheral equipment specifications in the manual may be exceeded when the following three criteria are met:

1. The actual U-Axis moment is less than or equal to the maximum U-Axis moment based on the specifications.
2. The actual wrist moment is less than or equal to the maximum wrist moment based on the specifications.
3. The actual combined payload of wrist and upper arm are less than or equal to the combined wrist and upper arm specification payloads.

In all cases, accurate wrist and upper arm payload information **must** be entered into the Tool and ARM Control files respectively. It is also the customer's responsibility to properly evaluate if the provided peripheral equipment mounting features on the robot are sufficient for attaching the increased equipment load.

Below are the steps for calculating and evaluating if the application is still within the robot's specification. An example and appendix for the variables are also provided at the end. (Use the following units for the various variables: payload = kg, length = m, moment = kgfm)

Step 1: Calculate (M_P)

- Refer to the robot manual's Basic Specifications (typically chapter 5 "Basic Specifications) and find the **wrist specification payload** (P_W) and **upper arm specification payload** (P_U).
- Refer to the robot manual's Moment Arm Rating chart (typically in chapter 6 "Allowable Load for Wrist Axis and Wrist Flange") and find the wrist specification payload's (P_W) **corresponding LB value** (L_B).
- Add the **upper arm length** (L_U) to the corresponding LB value (L_B) and multiply by the wrist payload to calculate the **maximum U-Axis moment due to wrist specification payload** (M_P).

$$M_P = P_W * (L_U + L_B)$$
$$kgfm = kg * (m + m)$$

Step 2: Calculate (M_U)

- Refer to the robot manual's Allowable Load section of Peripheral Equipment Mounts (typically in chapter 7 "System Application") and find the **allowable increase in U-Axis moment** (M_E).
- Add this value (M_E) to (M_P) from step 1 to calculate the **maximum U-Axis moment due to wrist and upper arm specification payloads** (M_U).

$$M_U = M_P + M_E$$
$$kgfm = kgfm + kgfm$$

Step 3: Calculate (M_A)

- Determine the **actual wrist payload** (P_{WA}) and **actual offset from the wrist flange** (L_{BA}) for the application.
- Determine the **actual upper arm payload** (P_{UA}) and **actual offset from the U-Axis center** (L_{UA}) for the application.
- Use the following formula to calculate the **U-Axis moment from actual equipment and payload** (M_A).

$$M_A = P_{WA} * (L_U + L_{BA}) + P_{UA} * L_{UA}$$
$$kgfm = kg * (m + m) + kg * m$$

Step 4: Evaluate Application

- The robot must satisfy the following relationships to be within specifications. If any of the following are not met, then please contact your Yaskawa representative before proceeding with the application.

$$M_A \leq M_U$$
$$P_{WA} * L_{BA} \leq P_W * L_B$$
$$P_{WA} + P_{UA} \leq P_W + P_U$$

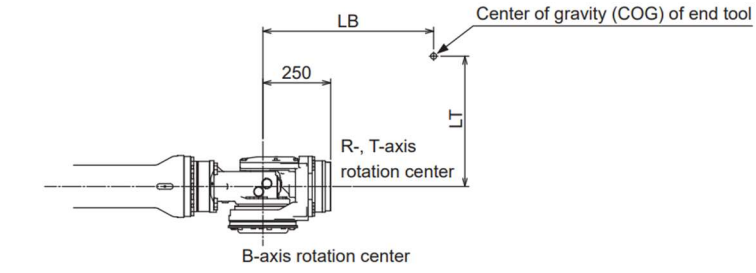
Example Calculation with GP250 Robot

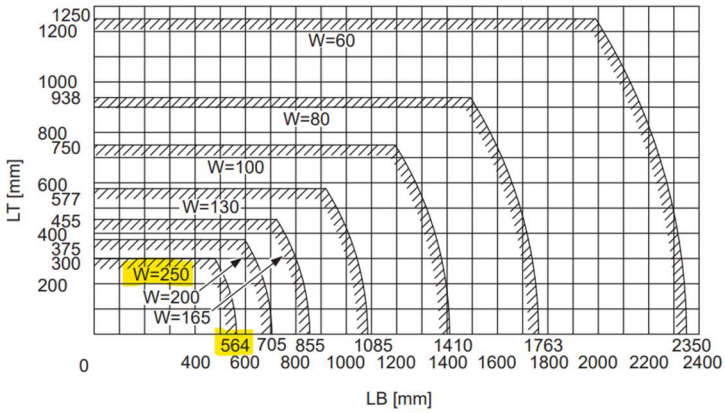
The GP250 is rated for 250 kg (P_W) at wrist and 50 kg (P_U) at upper arm.

Table 5-2: Basic Specifications (YR-1-06VX250-A20)

Item \ Type		YR-1-06VX250-A20	
Flange for cabling[1)]		Not-equipped	Equipped
Structure		Vertically articulated	
Degree of freedom		6	
Payload	Wrist part	250 kg	235 kg
	U-arm	50 kg	

A 250 kg load corresponds with an offset of 0.564 m (L_B) from the wrist flange.





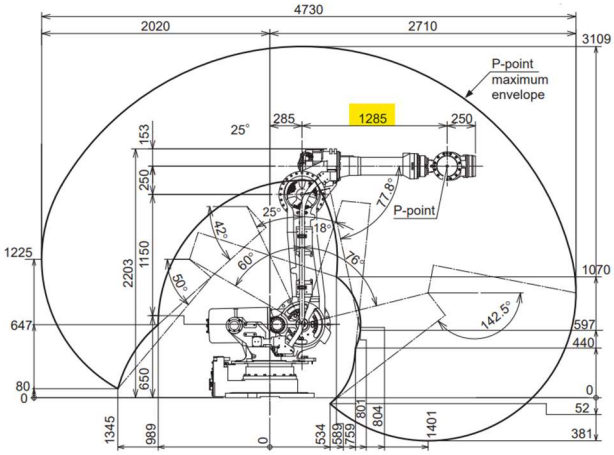
The peripheral equipment (upper arm load) is rated for 50 kg (P_U) with an allowable increase in upper arm moment of 5 kgfm (M_E).

7.1.1 Allowable Load

The allowable load on the peripheral equipment mounts of the U-arm (A1, A2, and A3) is 50 kg or less in total. And the amount of increase for the upper arm moment must be 49 N•m (5 kgf•m) or less when loading the allowable load. The allowable load on the peripheral equipment mounts (B) of the rotation head is up to 250 kg.

When a load is applied on the U-arm or the rotary head, the load setting must be performed. For setting procedures, refer to chapter 8.4 “ARM Control” in “YRC1000 INSTRUCTIONS (RE-CTO-A221)”.

The upper arm length is 1.285 m (L_U).



An application requires a 30 kg wrist tool (P_{WA}) with an offset of 1.2 m (L_{BA}). The peripheral equipment (upper arm load) is 60 kg (P_{UA}) with an offset of 0.3 m from the U-Axis center (L_{UA}).

Step 1:

$$M_P = P_W * (L_U + L_B)$$
$$M_P = 250kg * (1.285m + 0.564m) = 462.25kgfm$$

Step 2:

$$M_U = M_P + M_E$$
$$M_U = 462.25kgfm + 5kgfm = 567.25kgfm$$

Step 3:

$$M_A = P_{WA} * (L_U + L_{BA}) + P_{UA} * L_{UA}$$
$$M_A = 30kg * (1.285m + 1.2m) + 60kg * 0.3m = 92.55kgfm$$

Step 4:

$$M_A \leq M_U$$
$$92.55kgfm \leq 567.25kgfm$$

$$P_{WA} * L_{BA} \leq P_W * L_B$$
$$30kg * 1.2m \leq 250kg * 0.564m$$

$$P_{WA} + P_{UA} \leq P_W + P_U$$
$$30kg + 60kg \leq 250kg + 50kg$$

The application satisfies all criteria in step 4 and is acceptable for use, even though the peripheral equipment (upper arm load) is larger than the manual's specifications.

Appendix: Formula Variables

Variable	Units	Description
L_B	m	Offset from wrist flange corresponding to wrist specification payload
L_{BA}	m	Actual offset from the wrist flange
L_U	m	Upper arm length
L_{UA}	m	Actual offset from the U-Axis center
M_A	kgfm	U-Axis moment from actual equipment and payload
M_E	kgfm	Allowable increase in U-Axis moment
M_P	kgfm	Maximum U-Axis moment due to wrist specification payload
M_U	kgfm	Maximum U-Axis moment due to wrist and upper arm specification payload
P_U	kg	Upper arm specification payload
P_{UA}	kg	Actual upper arm payload
P_W	kg	Wrist specification payload
P_{WA}	kg	Actual wrist payload