Sustained Robot System Performance – Best Practices
6 Important Items to Consider ...and Get Good At

1. Equipment Specification
2. Support Personnel/Training
3. Preventative Maintenance
4. Programming
5. Rework Reduction
6. Tip’s and Tricks
Spec the Right Equipment for the Job

- Mutually Agreeable Solution
  - What is necessary technology
- Payload and Reach
  - Dedicated parts vs Flexibility
- Balance the Investment to the Application
Model the Cell

- Ensure feasibility
  - Prove it to yourself

- Reduce the Risks
  - Get the expected outcome

- Use on parts with difficult or compromised access and reach

- Plan part flow and layout

- Use accurate models solid geometry from design
Precision Pays Off
Eliminate the Guesswork
The single most important part to creating and sustaining a successful system is the end of arm tooling and process specific peripheral equipment - not the robot.
Choose the Positioner and Weld Position

Weld position and External Axis
Power Supplies - Smarter
Well Designed and Durable Peripherals

- Torches
- Reamers
- Cutters
Support Personnel

Define the Lines of Responsibility

- Who Programs?
- Who Does Weld Parameter Adjustments?
- Who Does PM’s, Daily, Weekly?

Is it easier to teach a technical person to weld or a welding person the computer technology?

Use the expertise that matches the job responsibility
Getting more people involved in the process and operation and making them accountable for the cell automatically ensures you have backup plan.
Training - Robot Operator and Welder

- Use Manufacturers Reps when possible
- Internally –
  - Modular Approach
  - Short Sessions
  - Better Attention and Focus
- Bulleted Items
- Train the Trainer Format
- Real World Analogies
Training

The Most Important Things You can do to Ensure Elevated Success

- Safety
- Welding Do’s and Don’ts – ROPS, etc
- Programming Do’s and Don'ts
- Different levels for the different support groups
- Different levels for the aptitude of the operator
Create Operator Help Sheets...

1. Wirefeed Issues
2. Welding Errors – Arc ignition
3. Water/gas Errors
4. Collision Detection
5. Positioner enables
6. Work Stop and Reset
7. Searching\Offsets
8. Touch sense errors
9. Out of range (MOVJ vs. MOVJ)
10. Step fwd/back
11. Power loss /reboot

....especially for interventions
Preventative Maintenance

<table>
<thead>
<tr>
<th>Step</th>
<th>Task Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Remove and clean robot cup and insulator/gas diffuser. Replace if deteriorated.</td>
</tr>
<tr>
<td>2</td>
<td>Assure gas ports are free of debris. Follow Crenlo Process. Standard 228 for cleaning instructions if obstructed.</td>
</tr>
<tr>
<td>3</td>
<td>Replace contact tip and reassemble torch (see PS-228)</td>
</tr>
<tr>
<td>4</td>
<td>Check TCP (tool center point) (See PS-228)</td>
</tr>
<tr>
<td>5</td>
<td>Perform a visual check of robot for any abnormalities. Pay extra attention to wire feed area</td>
</tr>
<tr>
<td>6</td>
<td>Make sure no hoses are damaged</td>
</tr>
<tr>
<td>7</td>
<td>Verify the water chiller is full of water</td>
</tr>
<tr>
<td>8</td>
<td>Verify water flow indicator is lit.</td>
</tr>
<tr>
<td>9</td>
<td>Make sure Anti-spatter reservoir is full</td>
</tr>
<tr>
<td>10</td>
<td>Clean torch reamer station</td>
</tr>
</tbody>
</table>

- TPM Daily Startup Check sheets
- Visual Aids
# Monthly and Yearly Checks

## Preventive Maintenance Report

**IRB2400**

<table>
<thead>
<tr>
<th>Date of Service:</th>
<th>Technician</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application:</td>
<td>Robot#</td>
</tr>
<tr>
<td>Hr Meter:</td>
<td>Serial No.</td>
</tr>
</tbody>
</table>

(Reference IRB2400 Product Manual)

### A. Robot Mechanical Arm

<table>
<thead>
<tr>
<th>Item</th>
<th>Maintenance Description</th>
<th>Status</th>
<th>Notes/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visual check of mechanical unit for external arm damage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Check manipulati is securely mounted</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Test operation functionality of brakes/brake release buttons</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Visual check for fluid/oil leaks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Inspect for loose or damaged cables &amp; connectors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Inspect for loose or missing bolts/fasteners</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Inspect for damage to Axis 1 mechanical stop, &quot;stop pin&quot;, change if bent</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Check for excessive play/backlash in Axis 4,5,6 gearboxes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Inspect &amp; tighten end of arm/cooling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Measure Serial Measurement Board (SMB) battery voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Robot power off &amp; battery plugged in &gt;7.2VDC, 10VDC for Li battery)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### B. Mechanical Arm Lubrication

<table>
<thead>
<tr>
<th>Item</th>
<th>Maintenance Description</th>
<th>Status</th>
<th>Notes/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Inspect oil level Axis 5,6 (wrist)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Change oil/Axis 5 gearbox as required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Change oil/Axis 6 gearbox as required</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Programming Best Practices

- Lead Programmer
  - Secondary help if necessary

- Work Design Document (A Kodak Moment)
  - Spell out the programming rules and best practices

- Ensure Consistency
Programming Best Practices

- Headers
- Comments
- Break it up
- Flexibility
- Quality

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**MODULE DCCAB**

| ! Version: 1.0 11/14/2011 1 Program Exported from Robotstudio Text Edited and Commented. |
| ! Practical Robotic Solutions 2009 |

```cpp
ROC LPathS2()
{
    !
    !Note:
    !Location: Underside of Left Console for J and Lynx
    !*******************************************************************************
    Activate\Stat;
    PDispSet;
    MoveL [[132.13, -745.25, 881.93], [0.062502, -0.997316, 0.002469, -0.145935], [-1, 0, 0, 0]];
    MoveL [[54.14, -193.47, 797.62], [0.596297, 0.24253, -0.763535, -0.050444], [-2, 0, 0, 0]];
    Search_ID peOffset_1, [[544.76, -211.57, 655.46], [0.662548, 0.032957, -0.743981, 0.0]];
    Search_ID peOffset_1, [[544.8, -206.53, 645.9], [0.662548, 0.032957, -0.743981, 0.0]];
    MoveL [[544.39, -195.24, 676.23], [0.556273, 0.324273, -0.763456, -0.050441], [-1, 0, 0, 0]];
    DefEscapePath "\\Z\_Value:=75;"
    PDispSet: peOffset_1;
    MoveL [[306.52, -175.74, 669.65], [0.396033, 0.456363, -0.775312, 0.188056], [-1, 0, 0, 0, 0]];
    Arc\On, [[339.88, -221.2, 635.75], [0.346274, 0.476193, -0.794465, 0.148851], [-1, 0, 0, 0, 0]];
    Arc\Off, [[304.49, -219.81, 634.91], [0.346274, 0.476193, -0.794465, 0.148851], [-1, 0, 0, 0, 0]];
    MoveL [[304, -186.44, 675.53], [0.346274, 0.476193, -0.794465, 0.148851], [-1, 0, 0, 0, 0]];
    MoveL [[455.04, -159.07, 664.21], [0.185188, 0.795645, -0.418404, 0.396977], [-1, -1, 0, 0, 0]];
    Arc\On, [[455.03, -222.82, 634.54], [0.185188, 0.795645, -0.418404, 0.396977], [-1, -1, 0, 0, 0]];
```
Search Methodology

- Plan the searches
  - What direction does the part move.
  - 2d vs 3d search
  - Which one first?

- Searches - perpendicular to the surface that moves
Rework Reduction Technician Tracking Sheets
Utilizes robot touch sense to ID cabs and choose the correct robot program with the multiple models.

Uses sensors in fixture to apply the correct clamps automatically for the different cab models.

A PLC checks the clamps with electronics sensors to ensure the cab is securely clamped before the weld cycle is started.

New cab models were offline programmed in Robot Studio to reduce downtime to current production weld line.

Robot Studio provides more accurate torch angles which eliminates eyeballing error during programming.
TCP and Tracking

Importance of TCP Accuracy

- Ensures path following accuracy
- Improved interpolation
- Circular objects require less targets
- Seam Tracking correction vectors
Robot Calibration

Precision Pays Off
The Effect on Tracking

**weave_shape** *(weld weave shape)*

Data type: num

The shape of the weaving pattern in the weld phase.

<table>
<thead>
<tr>
<th>Specified value</th>
<th>Weaving pattern</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No weaving.</td>
</tr>
<tr>
<td>1</td>
<td>Zigzag weaving as illustrated in Figure 39.</td>
</tr>
</tbody>
</table>
Accurate TCP and Calibration

Result

Precision Pays off!
Part Mistake Proofing

- Color Coding
  1. Kit Carts
  2. Fixtures
  3. Work instruction
     Check Sheets
- Reduce defects

Processes – Model Complexity
Processes – Visual Factory

- QDIP Boards
  - Charts posted on the line to visually show safety, quality, delivery and productivity
  - Communicates today’s plan and prior history

- Daily Hour by Hour Boards
  - Operators record times when units advance to the next station
  - Helps set pace
  - Quick visual indicator of issues
  - Checked by supervisor 4 times/day, superintendent 2/day
Tips and Tricks

- Use down hand positioning (=/-15 degrees) for good toe fusion and appearance.
The Burn back Nemesis

What to do ....
Grounding Best Practices

- Isolate the work lead and process equipment
- Star Configuration
- Bonded Metal to Metal
Work Piece Grounding

The Bad

The Good
Cable Management

The Bad
Cable Management

The Good
Tip and Tricks – Wirecast

- Best Current Transfer at the tip
- Reduce Burn backs
Best Practices

Good Robot Welding Applications

- Prefer filet joints with stable part location
  - Tab and Slot
  - Fillets vs Grooves
- Minimal fixturing required in robot weld station with adaptive features of hardware
  - Seam Finding
  - Seam Tracking
Cable Management

Label Everything

Insist that Cables Be Off of the Floor
Comments – Questions?