Tool 1: Histogram

Case Study Overview: TechElectro Manufacturing

Company: TechElectro Manufacturing

Product: Printed Circuit Boards (PCBs) for Automotive Applications

Problem: Customer returns increased from 1.2% to 4.5% over the past quarter

Impact: Major automotive contract at risk

Your Role: Quality improvement team member tasked with applying the 7 Basic Quality Tools

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TOOL 1: HISTOGRAM 📊

1. Background

The team suspects that temperature variation in the reflow oven is causing both solder bridges (too hot) and cold solder joints (too cold). The oven should maintain 227°C (target) with tolerance limits of ±3°C (225-230°C). However, operators report seeing the temperature display fluctuate significantly.

Current Situation:

- Reflow oven has 4 heating zones
- Temperature monitored by one thermocouple in Zone 3
- Last calibration was 6 months ago (spec: every 90 days)
- No systematic temperature logging
- Operators adjust settings based on "feel" and visual inspection

2. Dataset / Key Information

Data Collection Method:

- Measurements taken every 30 minutes over 2 production days
- Zone 3 of reflow oven (critical zone)
- Measured with calibrated external thermometer

Specifications:

- **Target:** 227°C
- **Lower Specification Limit (LSL):** 225°C
- **Upper Specification Limit (USL):** 230°C

RAW DATA - 100 Temperature Measurements (°C):

```
Sample 1-25:
228.0, 229.9, 222.7, 235.5, 231.4, 226.9, 234.9, 228.2, 230.4, 228.7,
235.3, 230.5, 223.6, 225.6, 230.3, 235.7, 226.8, 235.2, 233.3, 236.5,
237.1, 233.2, 227.1, 225.1, 231.6

Sample 26-50:
233.3, 224.5, 224.5, 231.1, 227.9, 235.6, 232.4, 229.8, 223.0, 229.5,
225.6, 230.2, 235.5, 233.9, 227.5, 229.5, 233.1, 231.8, 228.0, 229.8,
224.0, 228.9, 230.1, 226.9, 225.5

Sample 51-75:
231.3, 235.3, 223.1, 232.6, 224.6, 225.7, 229.5, 232.9, 226.4, 227.5,
226.9, 226.9, 226.8, 233.3, 226.7, 231.0, 228.0, 236.6, 227.1, 226.1,
221.1, 229.3, 226.7, 232.4, 229.3

Sample 76-100:
226.9, 226.5, 227.0, 235.8, 227.9, 233.9, 226.4, 222.4, 229.4, 233.3,
223.7, 227.9, 224.8, 234.8, 230.4, 231.1, 232.8, 225.7, 232.5, 227.3,
234.2, 228.6, 229.7, 225.5, 235.4
```

Your Task: Create a histogram with appropriate bins (2°C intervals), calculate statistics, and analyze the distribution.

3. Required Deliverables

Using the Histogram template, complete the following:

1. **Create a histogram** showing the temperature distribution

    - Use appropriate bin sizes (suggest: 2°C intervals)

2. **Calculate key statistics:**
    - Average (mean) temperature
    - Standard deviation
    - Range (highest - lowest)
    - Percentage of measurements outside specification limits
3. **Answer analysis questions:**
    - Is the process centered on target?
    - What percentage is out of specification?
    - What is the shape of the distribution (normal, skewed, bimodal)?
    - What does the distribution tell us about the problem?
4. **Write conclusions** (150-200 words) about what the histogram reveals

4. Tips for Success

✓ **Tip 1:** Choose bin width carefully. Too many bins = hard to see pattern. Too few bins = lose important detail. For this data, 2-3°C intervals work well.

✓ **Tip 2:** Look at the SHAPE:

- Normal (bell curve) = common cause variation
- Skewed = process shifted in one direction
- Bimodal (two peaks) = two different conditions/processes

✓ **Tip 3:** Compare average to target. Even if data is "in spec," being off-target indicates a problem.

✓ **Tip 4:** Use Excel's built-in histogram tool or FREQUENCY function for accurate counting.

✓ **Tip 5:** A histogram shows WHAT is happening (the distribution). You'll need other tools (fishbone, scatter diagram) to find out WHY.

5. Sample Solution & Analysis

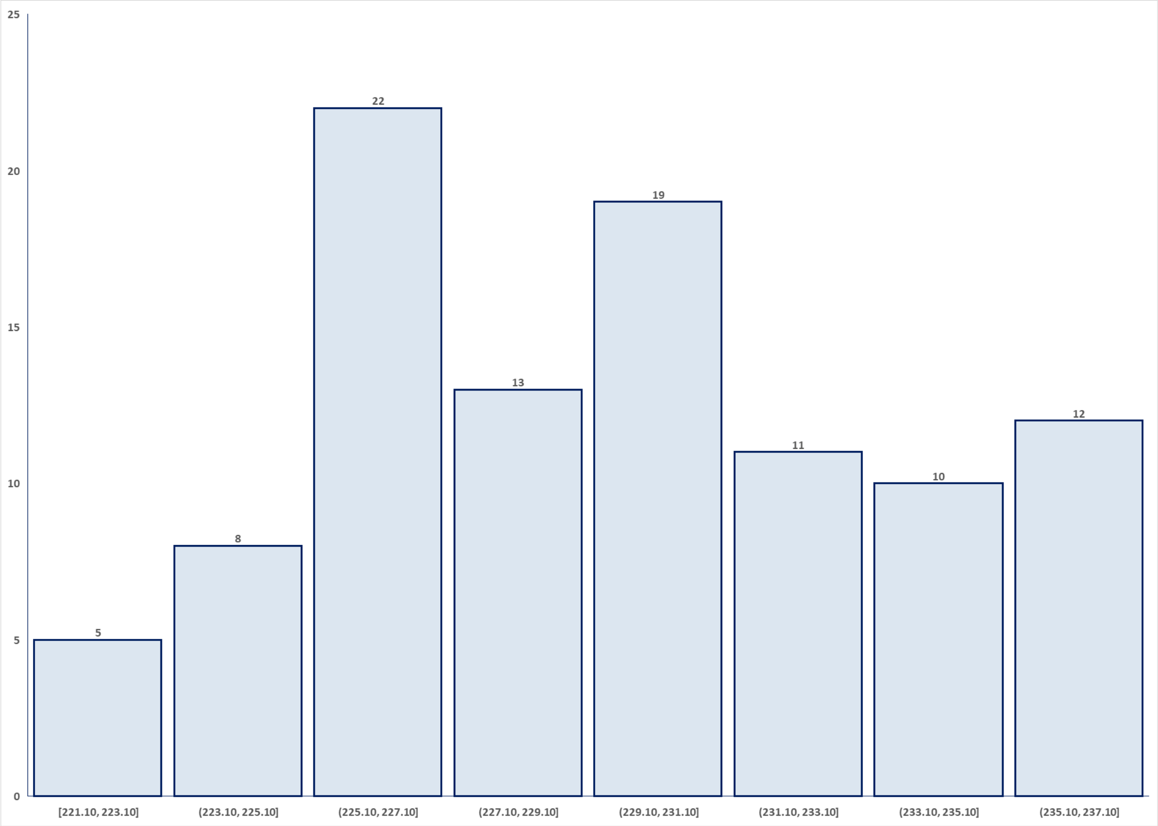
Key Statistics:

- **Mean:** 229.464°C (2.464°C above target!)

- **Standard Deviation:** 3.861°C
- **Range:** 221.1°C to 237.1°C (16.0°C total variation)
- **Out of Spec:** 54% of measurements
    - Below LSL (<225°C): 12%
    - Above USL (>230°C): 42%

Distribution Shape: Right-skewed with extended high-temperature tail:

Visual Representation:



Sample Conclusions:

"The histogram reveals a serious process control problem with the reflow oven. The right-skewed distribution indicates that the oven consistently operates above target temperature with frequent high-temperature excursions. With 54% of measurements outside specification limits and a mean 2.464°C above target, the process is both off-center and highly variable.

The wide 16.0°C range is unacceptable for precision soldering and exceeds the entire specification window by more than 3x. This explains why we see both solder bridges (from high temperatures, 42% above USL) and cold solder joints (from low temperatures, 12% below LSL).

The right-skewed pattern strongly suggests systematic causes such as:

1. Calibration drift causing the baseline temperature to be too high
2. Control system instability causing temperature overshoot
3. Environmental temperature changes affecting the oven (though pattern suggests baseline shift rather than cyclical variation)
4. Inadequate thermal control allowing temperature spikes

Further investigation using cause-and-effect analysis (fishbone diagram) and scatter diagrams is essential to identify whether calibration drift, control system malfunction, or environmental factors are responsible.

Priority action: The oven requires immediate recalibration and the setpoint should be lowered by approximately 2.5°C to center the process. The control system should also be evaluated for stability issues causing the extended high-temperature tail. With over half the output out of specification, this is a critical quality issue that directly threatens our automotive contract."