(Footnote)

The survey was conducted in 2016 by collecting information from factories of foods, beverages, steels, pulp and paper mill, semiconductors, electrical equipment, electronics devices, communication devices, automotive, chemical plant, precision instruments, and metal processing. The survey included information from companies that provide devices and equipment with communication functions to factories. Additional information available on the internet was also included in the survey results.

Table 2 List of wireless applications and communication requirements for equipment control

Controlling, operating and commanding of production equipment and auxiliary equipment

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 1 | control of liquid injection | water volume | 64 | once per 1 min. | 100 msec. | 1 |
| 2 | operation of conveyor control switch | PLC | 16 | 5 per day | 100 msec. | 5 |
| 3 | AGV control | Go signal, positioning | 100 | once per 1 min. | 100 msec. | 1 to 10 |

Table 3 List of wireless applications and communication requirements for Quality Supervision -1

Checking that products are being produced with correct precision

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 4 | size inspection by line camera (line sensor) | size measurements | 30K | once per sec. | 5 sec. | 1 |
| 5 | detect defect state | defect information (video) | 500 | once per 100 msec. | 500 msec. | 1 |
| 6 | detect incorrect operation | anomalous behavior due to adding impurities | 1M | once per sec. | 10 sec. | 1 |

Table 4 List of wireless applications and communication requirements for Quality Supervision -2

Checking that manufacture is proceeding with correct procedure and status

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Data Size (bytes) | Communication Rate | Arrival Time Tolerance | Node density |
| 7 | sensing for managing air　conditioning | air stream | 64 | once per sec. | 1 min. | 1 |
| 8 | monitoring of equipment | state of tools, disposables | a few hundreds | once per sec. | 1 sec. | 2 |
| 9 | counting number of failsafe wrench operations | pulses | 64 | once per 1 min. | 100 msec. | 10 |

Table 5 List of wireless applications and communication requirements for Factory Resource Management -1

Checking that the factory environment is being correctly managed

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 10 | managing clean room (booth)dust count | Dust count (particles) | 32 | once per min. | 5 sec. | 5 |
| 11 | managing carbon dioxide concentration | CO2 concentration | 16 | once per min. | 5 sec. | 2 |
| 12 | preventive maintenance | machine’s temperature | a few tens | once per every event | 1 sec. | 2 |

Table 6 List of wireless applications and communication requirements for Factory Resource Management -2

Monitoring movement of people and things

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 13 | movement analysis | wireless beacon | a few tens | twice per sec. | few secs. | 1 o 10 |
| 14 | measuring location of people and things | transmission time (phase), radio signal strength, etc. | a few tens of thousands | once per sec. | 1 sec. | 2 |
| 15 | measuring location of products | location of products during manufacture | 200 | once per sec. | 1 sec. | 20 |

Table 7 List of wireless applications and communication requirements for Factory Resource Management -3

Checking the management status of equipment and materials (stock)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 16 | racking assets(beacon transmission) | information of equipment and things | 200 | once per sec. | 1 sec. | 20 |
| 17 | tracking parts, stock | RFID tag | 1K | 1~10 times per 30 mins. | 100 msec. | 3 to 30 |

Table 8 List of wireless applications and communication requirements for Factory Resource Management -4

Checking that production equipment are being maintained

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 18 | managing facilities | activity of PLC | 4K | once per sec. ~ once per min. | one ~ few tens of secs. | 1 to 10 |
| 19 | measuring energy consumption | energy, current | 64 | once per min. | 1 min. | 1 |
| 20 | monitoring revolving warning light | defect information | 100 | few times per hour | 1 sec. | 25 |

Table 9 List of wireless applications and communication requirements for Factory Resource Management -5

Appropriate recording of work and production status

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 21 | work record | text data | 100 | once per min. | 1 sec. | 9 |
| 22 | work proof | certification data | 1K | once per 3 hours | 10 sec. | 9 |
| 23 | Checking completion of process | image, torque waveform | 100K | once per 1 sec ( up to 1 min.) | 200 msec. | 1 to 14 |
| 24 | OK, NG | 100 | once per 1 sec ( up to 1 min.) | 200 msec. | 1 to 14 |

Table 10 List of wireless applications and communication requirements for Display -1

Providing appropriate work support

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 25 | work commands (wearable device) | image | 600 | once per 10 secs. ~ 1 min. | 1~10 sec. | 10 to 20 |
| 26 | view work manual | text data | 100 | once per hour | 10 sec. | 9 |
| 27 | display information (image display) | image (video/still image) | 5M | once per 10 secs. ~ 1 min. | few sec. | 1 to 5 |

Table 11 List of wireless applications and communication requirements for Display -2

Visually display whether the process is proceeding without congestion or delay

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 28 | managing congestion | counter (number or remaining number) | few bytes | once per 10 secs. ~ 1 min. | few sec. | 1 to 10 |
| 29 | managing operation activity | activity of PLC | 128 | once per hour | 100 msec | 2 |
| 30 | displaying revolving warning light | ON/OFF | few bytes (a few contact points) | once per 10 secs. ~ 1 min. | 0.5~2.5 sec. | 30 |

Table 12 List of wireless applications and communication requirements for Display -3

Visualization for monitoring production status

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 31 | managing operation activity | image | 6K | 30 per sec (30fps) | 500 msec. | 1 |
| 32 | supporting workers | PLC | 200 | once per 10 secs. ~ 1 min. | 500 msec. | 5 |
| 33 | supporting maintenance | image, audio | 200 | once per 100 msec. | 500 msec. | 1 |

Table 13 List of wireless applications and communication requirements for Human safety

Ensuring the safety of worker

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 34 | detecting dangerous operation | image | 6K | 10 per sec. (10fps) | 1 sec. | 1 |
| 35 | Collecting bio info for managing worker safety | vitals information  (wearable) | 100 | once per 10 sec. | 1 sec. | 9 |
| 36 | vitals information  (fixed, relay) | 200 | once per 1 min. | 5 sec. | 20 |
| 37 | gait | about 100K | ~10 per sec (1fps~10fps) | 1 min. | 10 to 20 |
| 38 | detect entry to forbidden area | body temperature, infrared | 2 | when event occurs | 1 sec. | 1 |

Table 14 List of wireless applications and communication requirements for others

Cases other than above

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| No. | Wireless application | | Communication requirements | | | |
| Purpose | Corresponding Information | Transmit Data Size (bytes) | Communication Rate | Delivery Time Tolerance | Node density |
| 39 | sending data to robot teaching box | coordinates | few hundred kilobytes | twice per year | less than 500 msec. (safety standard) | 10 |
| 40 | relay of images moving | video | 20K | 30 per sec. | 20 msec. | 5 |
| 41 | techniques, knowhow from experts | video, torque waveforms | 24K | 60 per sec. (60fps) | None | 1 |