

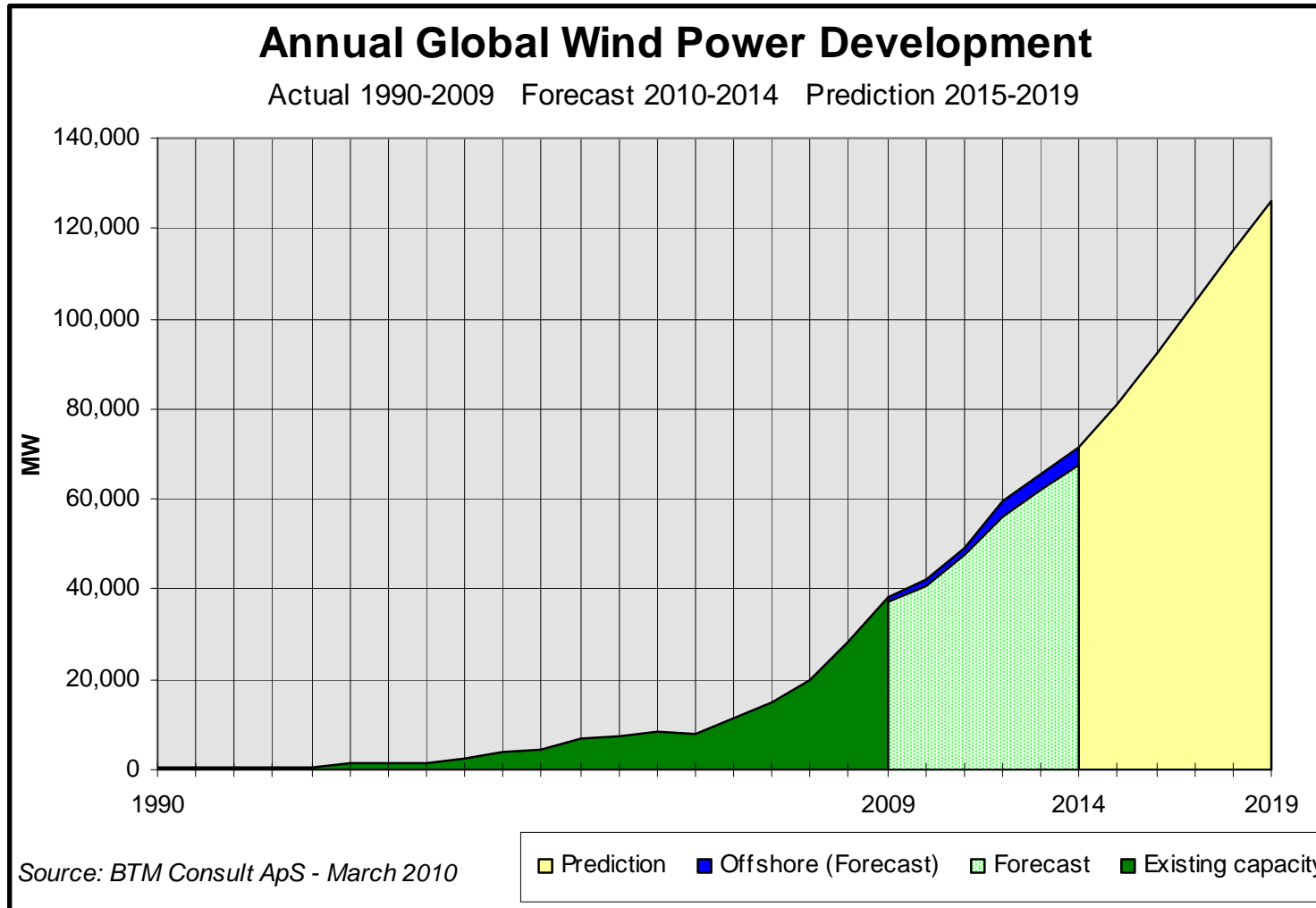
Improving Cooling of a Wind Turbine Generator by Uniform Cooling Air

**August, 2010
Hitachi, Ltd.
Japan**

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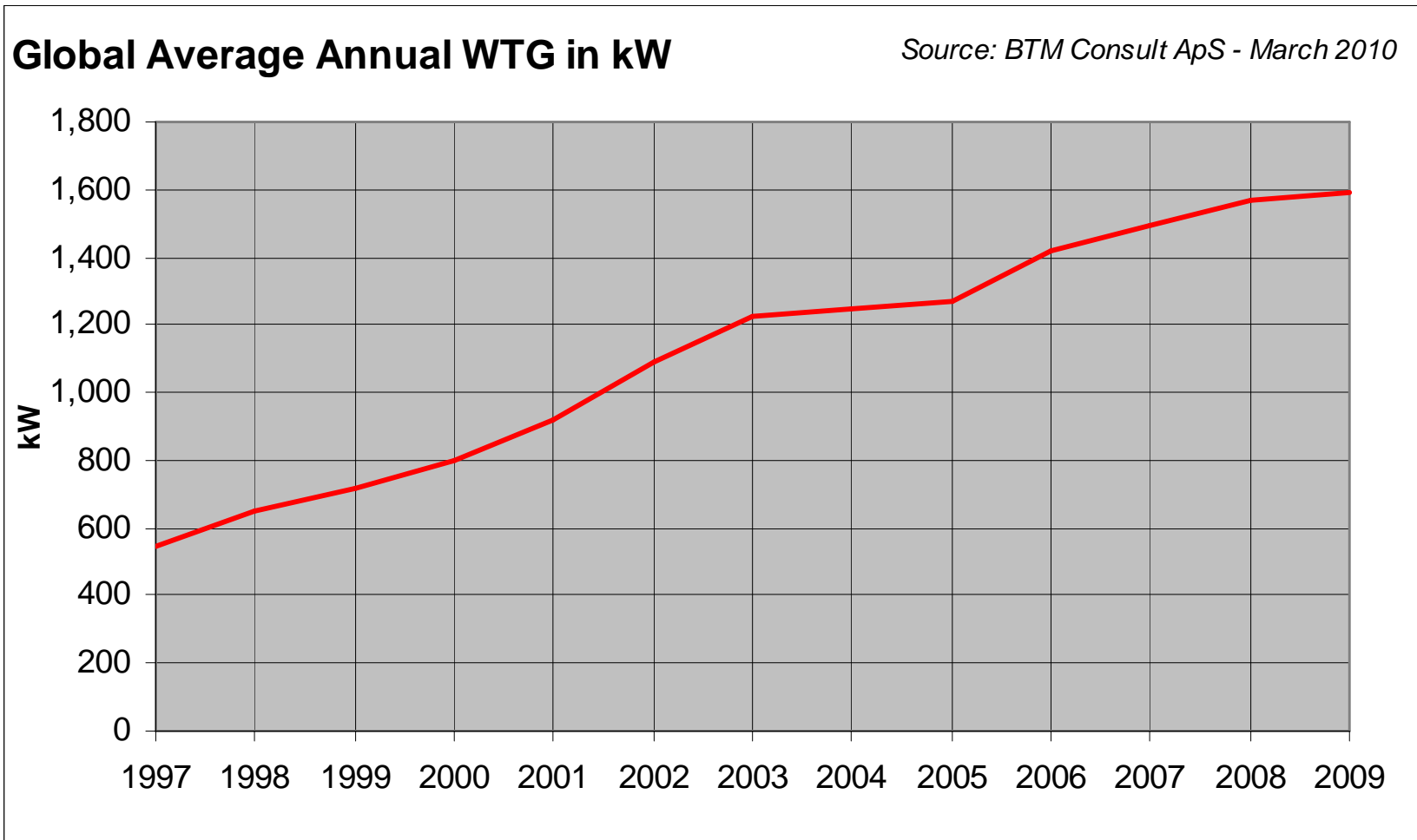
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1 . Introduction



The number of wind turbine has increased dramatically

1 . Introduction



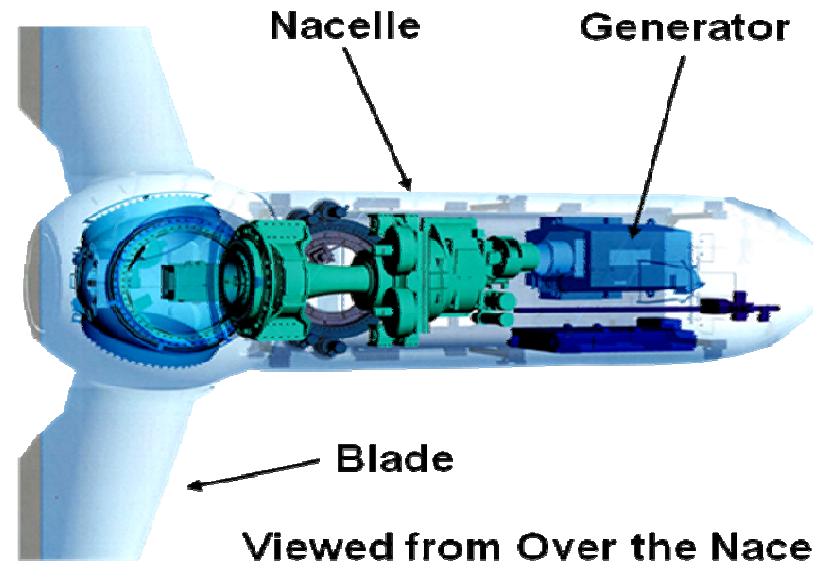
Average of Unit Power Output Reached over 1500 kW

- **Customer's (Tower Manufacturer) Requirement :**
 - ◆ **Light Weight & Compact Generator is Preferred for Limited Space**
- **Hitachi's (Generator Manufacturer) Problem :**
 - ◆ **Efficient Cooling System of Generator with Large Output**
- **Target of This Report :**
 - ◆ **Improving of Air Flow Distribution for Air to Air Cooler Pipes**

2 . Wind Turbine Generator



Nacelle



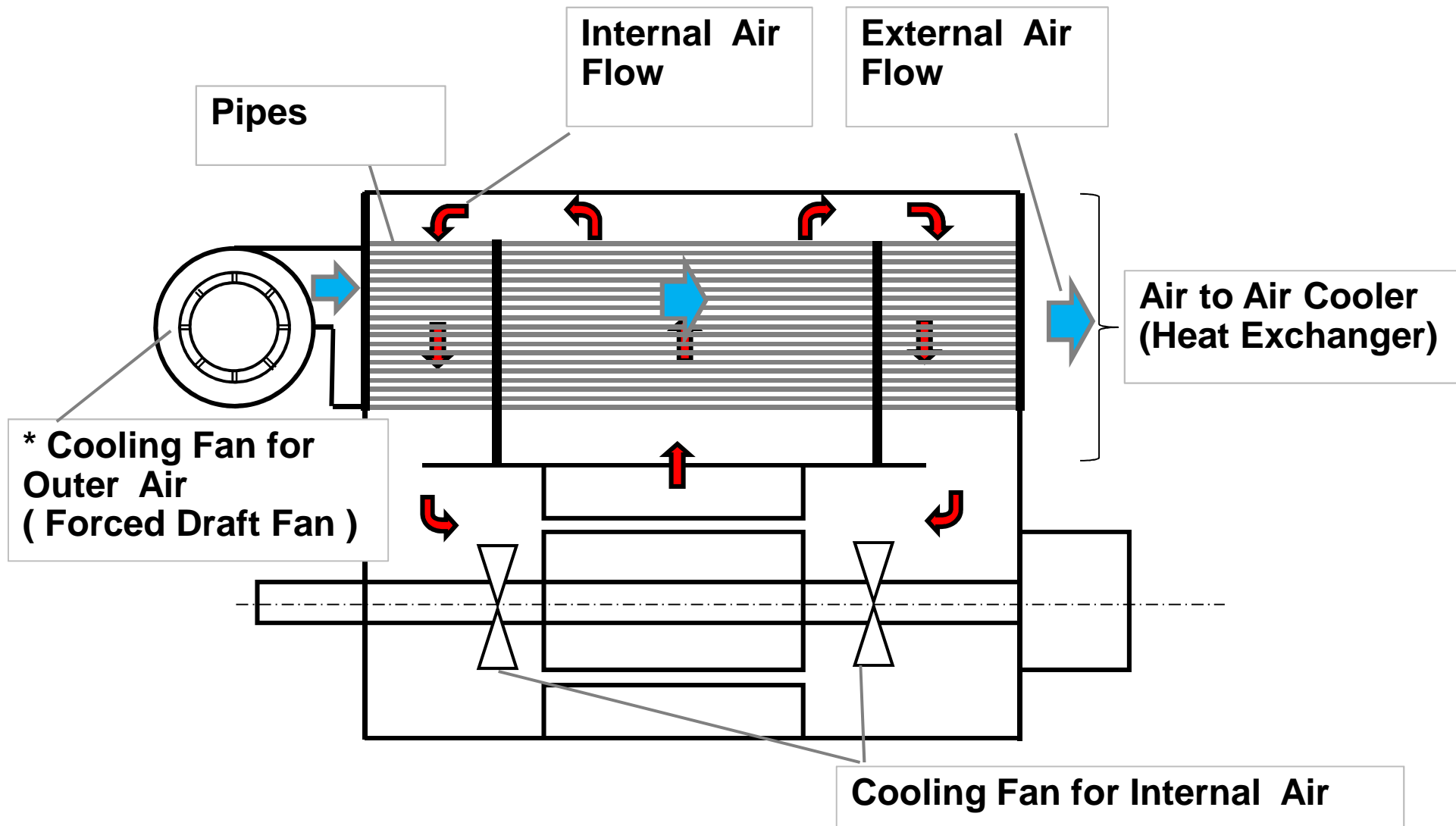
2 MW Class Wind Turbine

◆ **Tower Height 60 - 80 m**

◆ **Blade Dia. 80 m**

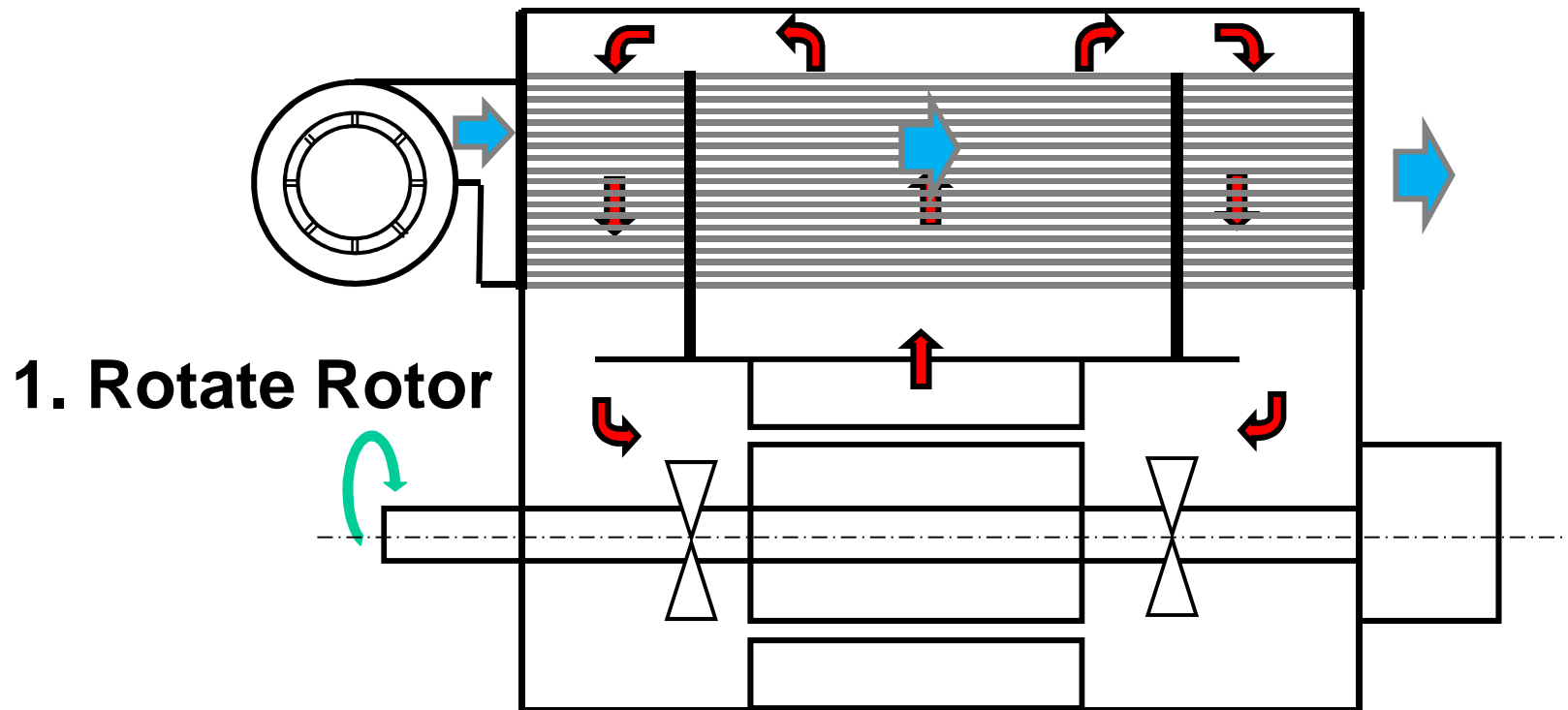
Generator is located in Nacelle

3 . Generator Structure



*** Forced Draft Fan is Required from Customer**

4. Supplied Outer Air 5. Exchanging Heat at Pipes to Cool Generator

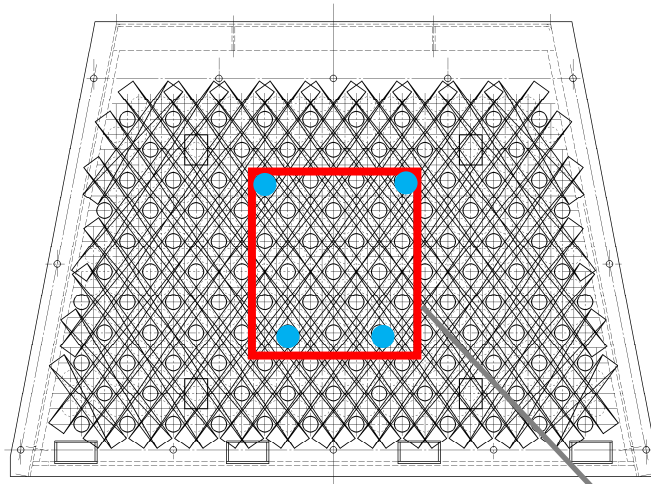


1. Rotate Rotor

2. Circulated Internal Air

3. Internal Air Removes Heat of Coils & Core

4 . Test Method (Image of Test Model)



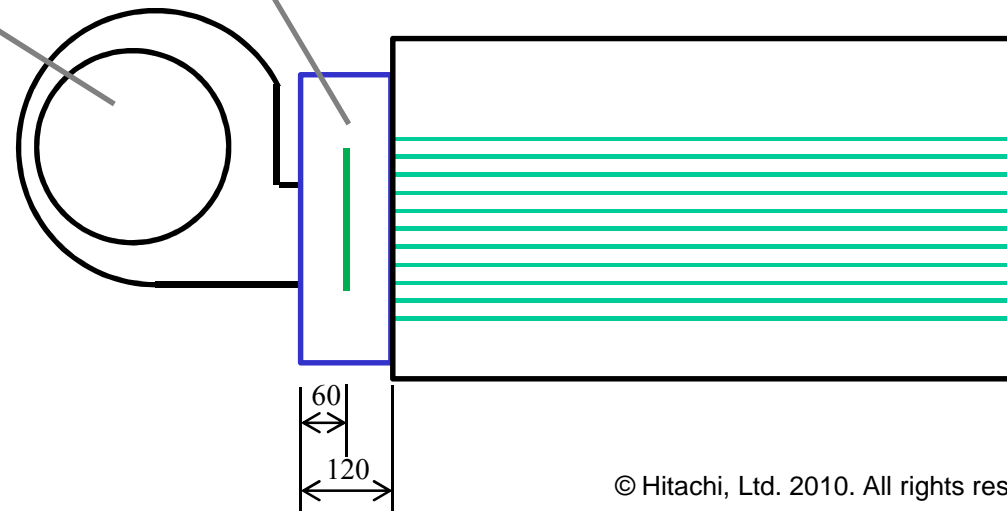
○ : 113 Pipes

(Viewed from Inlet Side)

Forced Draft Fan:

- ◆ 180 m³/min
- ◆ 1961 Pa
- ◆ 20 deg.C
- ◆ 2 Poles
- ◆ 3600 rpm

□ : Buffer Plate (300 x 400 mm)



4 . Test Method

No.	items	Specification	remarks
1	buffer plate	Length between fan outlet and surface of pipe inlet	120 mm
2		Set position	60 mm from fan outlet (set at half this length)
3		Size of fan-outlet opening	260 × 365 mm
4		Size of buffer plate (with holes (Photo 2) and without holes (Photo 3))	300 × 400 mm
5		Size of holes on buffer plate	10-mm hole diameter, 20-mm pitch, square arrangement
6	fan	centrifugal fan; cooling capacity: 180 m ³ /min; operating pressure: 1961 Pa motor for fan: 15 kW, 2 Pole rotation speed: 3000 rpm,	test nos. 1-1 to 1-3 and 2-1 to 2-3 slightly larger than fan-outlet opening test nos. 1-1 to 1-3; Photo 2

Specifications of Buffer Plate & Fan

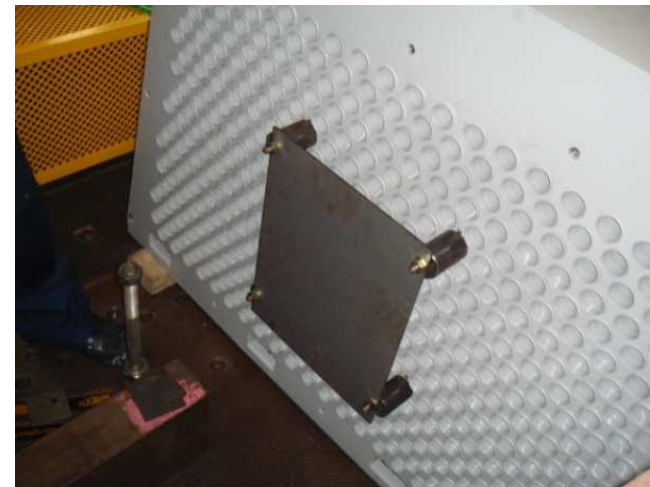
4 . Test Method



Over View of Test Model



Buffer Plate with Holes



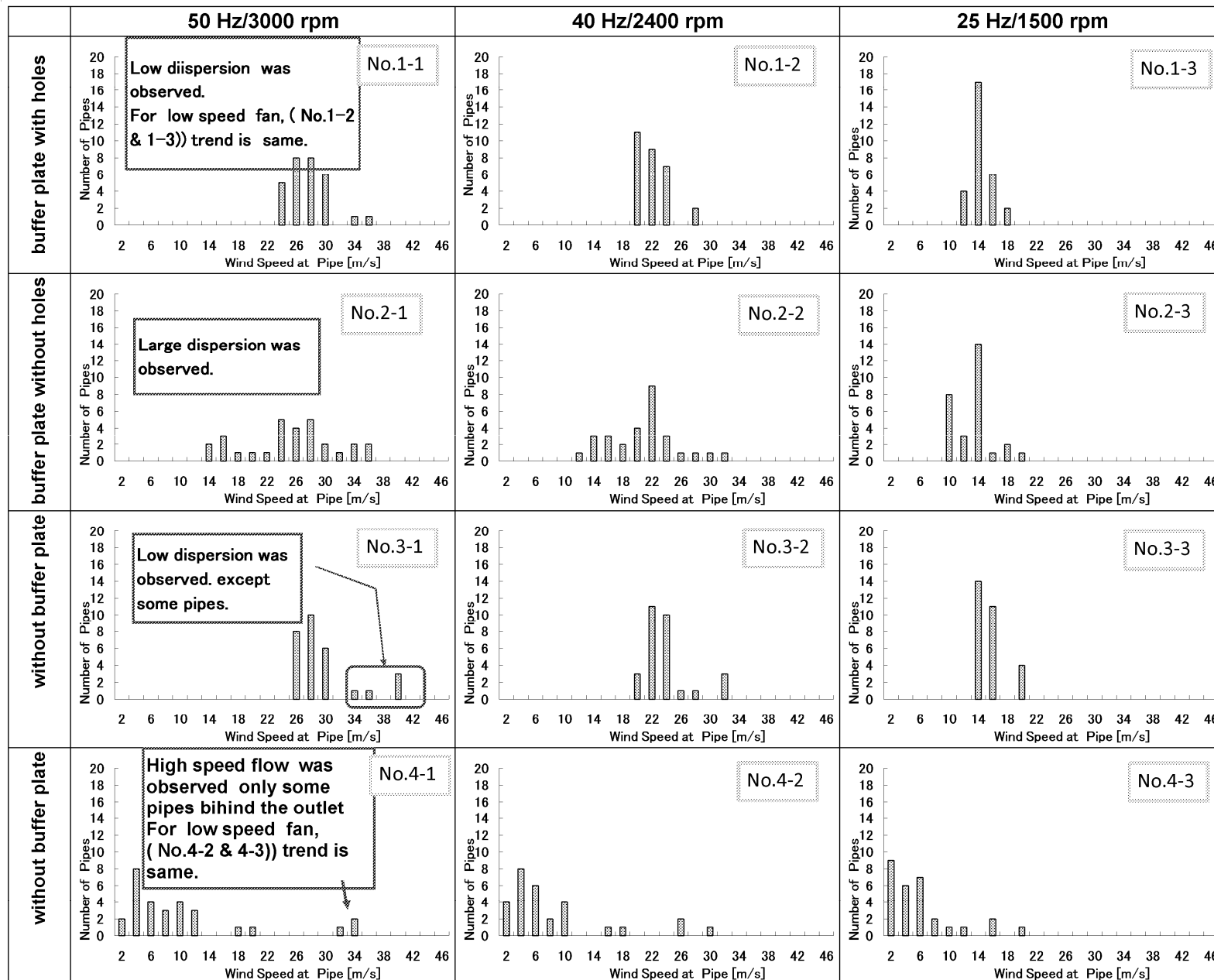
Buffer Plate without Holes

4 . Test Method (Test Cases)

No.	Air to Air Cooler Condition		Rotation Speed of Fan			Remarks
	Buffer Plate	Number of Pipes	3000 rpm (50 Hz)	2400 rpm (40 Hz)	1500 rpm (25 Hz)	
1	Buffer Plate with Holes	113 Pipes	1-1	1-2	1-3	
2	Buffer Plate without Holes		2-1	2-2	2-3	
3	Without Buffer Plate		3-1	3-2	3-3	
4		471 Pipes	4-1	4-2	4-3	Reference Test

12 Cases were Tested

5 . Test Results



Result

Good Uniform

Poor Uniform

Fair Uniform

Poor Uniform

To Get Good Uniform Cooling Air :

- 1) High Loss of Pressure (**Small Dia. Pipe**) is Required
- 2) Buffer Plate with Hole is Required **for more Uniform Dispersion**
- 3) Buffer Plate **without** Hole is **not** Required

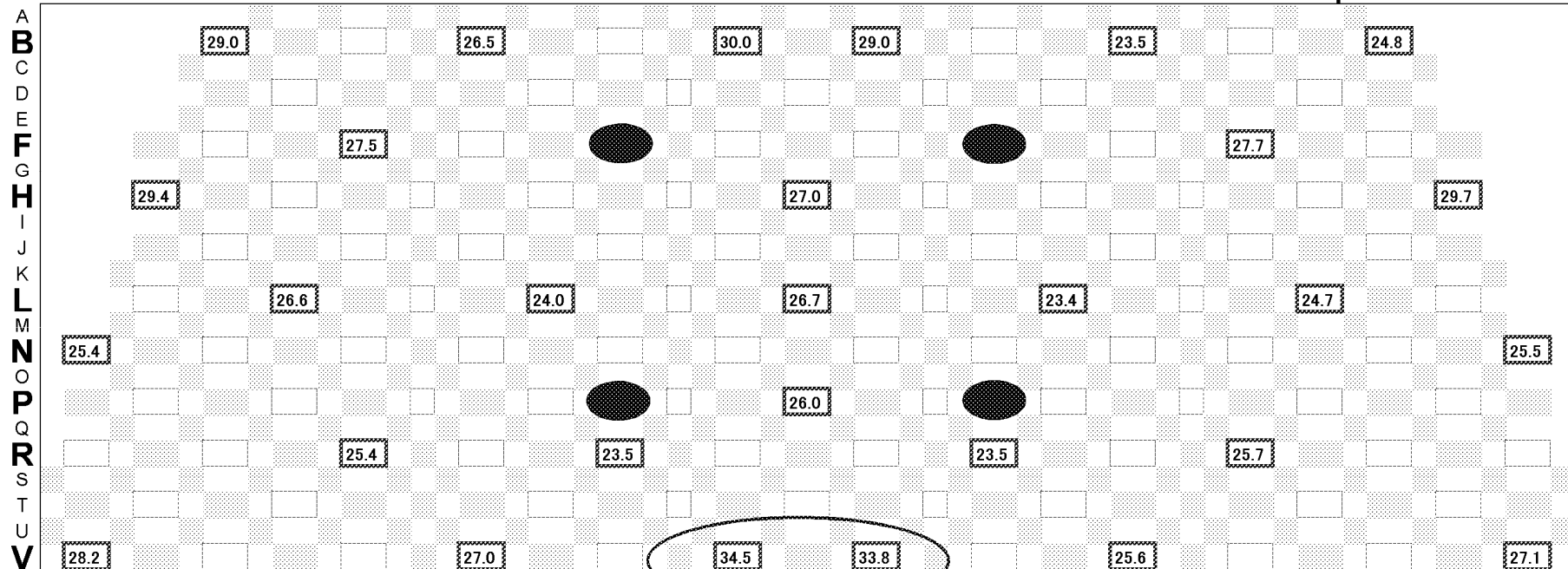
7 . Appendix (No. 1-1)

No.1-1 Measured Wind Speed at the External Air of Pipes

App. 1

average speed: 26.9 m/s
max. speed: 34.5 m/s
min. speed: 23.4 m/s

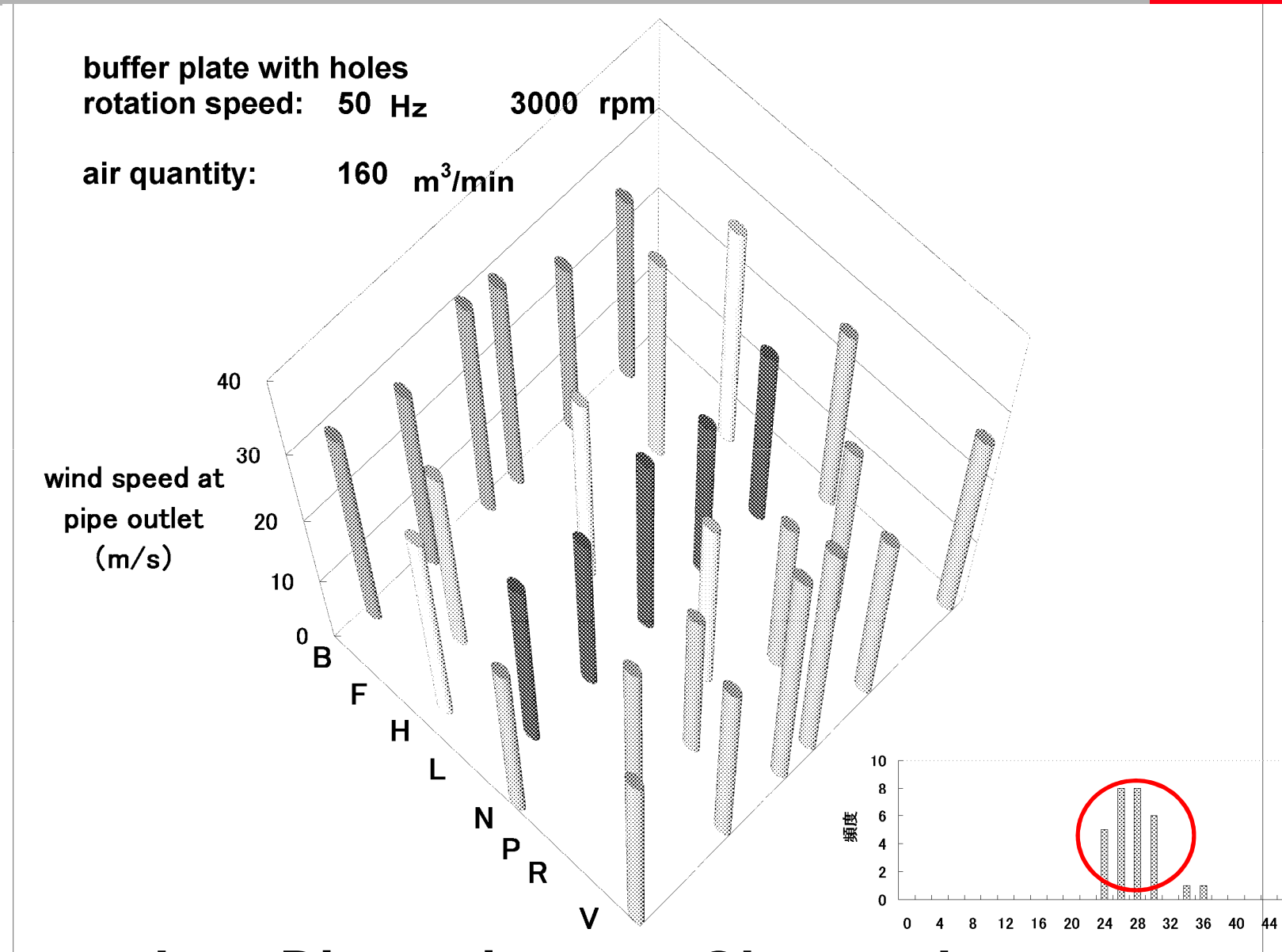
□ measured point ▨ closed pipes ● closed pipes for locking plate



High wind was observed at the outer outlet side of centrifugal fan

Low Dispersion was Observed

7 . Appendix (No. 1-1)



Low Dispersion was Observed

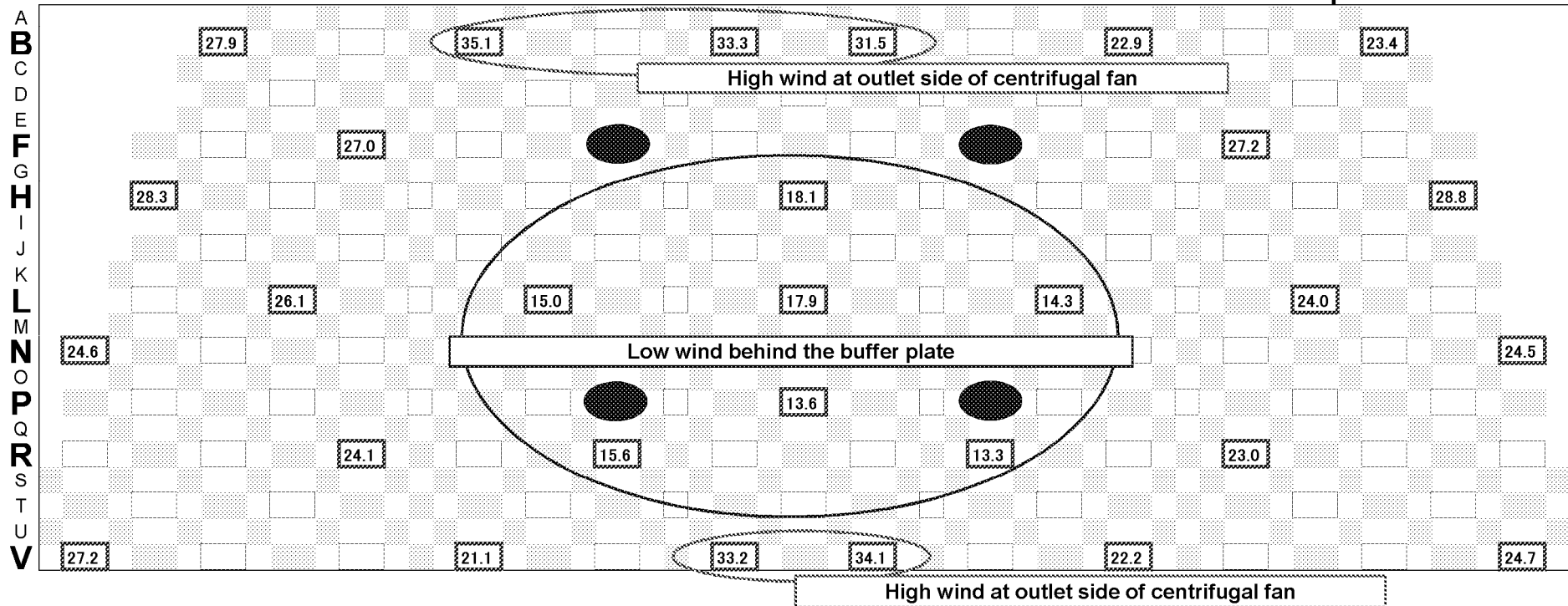
7 . Appendix (No. 2-1)

No.2-1 Measured Wind Speed at the External Air of Pipes

App. 4

average speed: 24.2 m/s
max. speed: 35.1 m/s
min. speed: 13.3 m/s

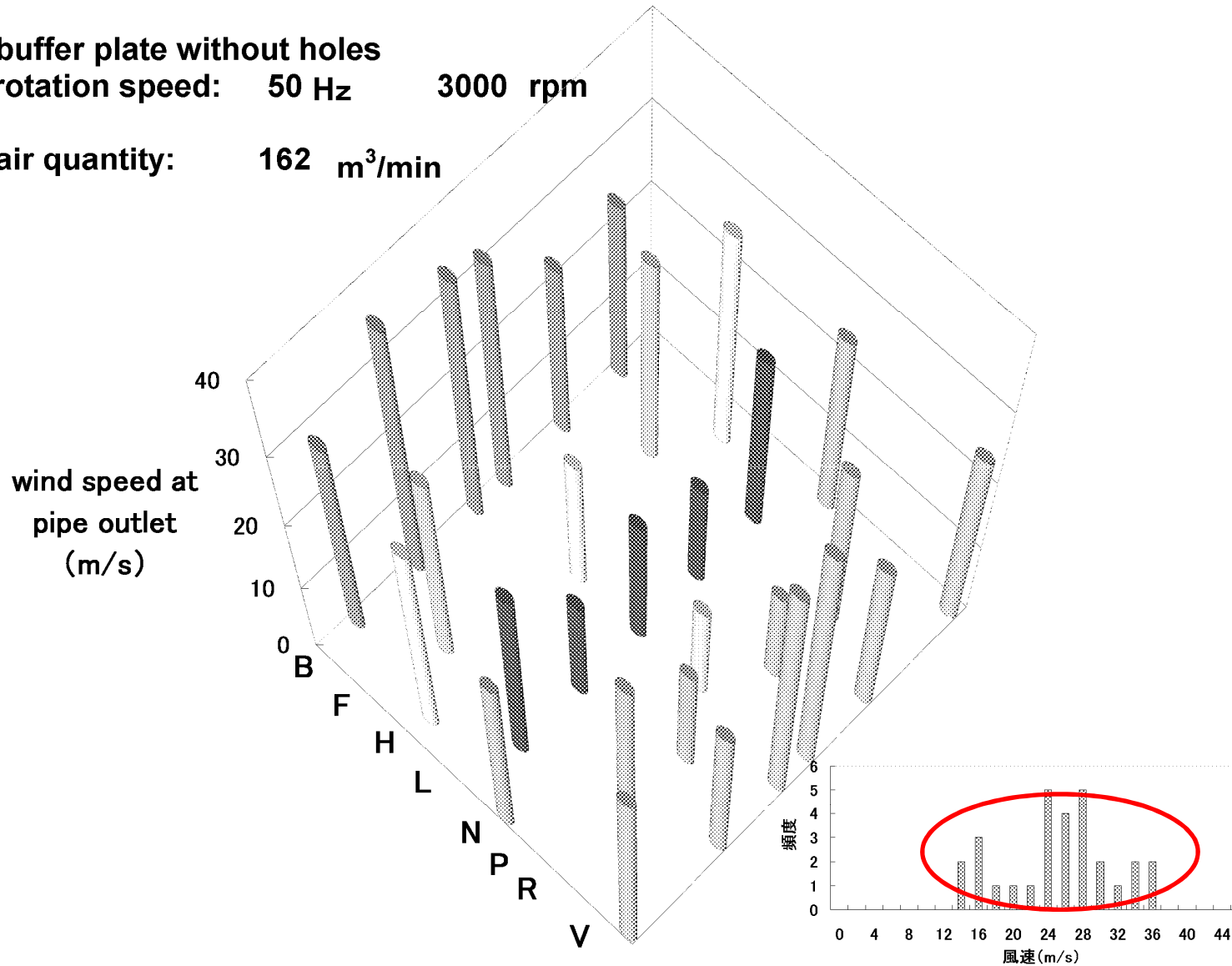
□ measured point ▨ closed pipes ● closed pipes for locking plate



Large Dispersion was Observed

7 . Appendix (No. 2-1)

buffer plate without holes
rotation speed: 50 Hz 3000 rpm
air quantity: 162 m³/min



Large Dispersion was Observed

7 . Appendix (No. 3-1)

No.3-1 Measured Wind Speed at the External Air of Pipes

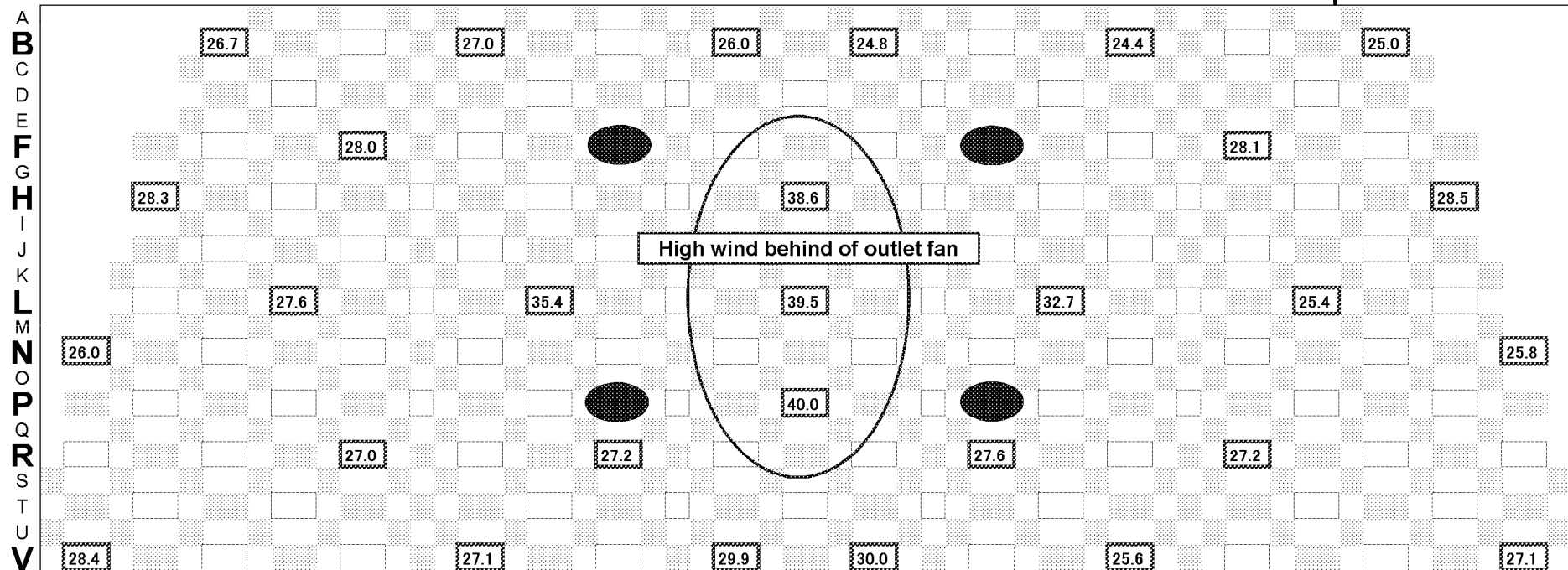
App. 7

average speed: 28.8 m/s

max. speed: 40.0 m/s

min. speed: 24.4 m/s

□ measured point ▨ closed pipes ● closed pipes for locking plate

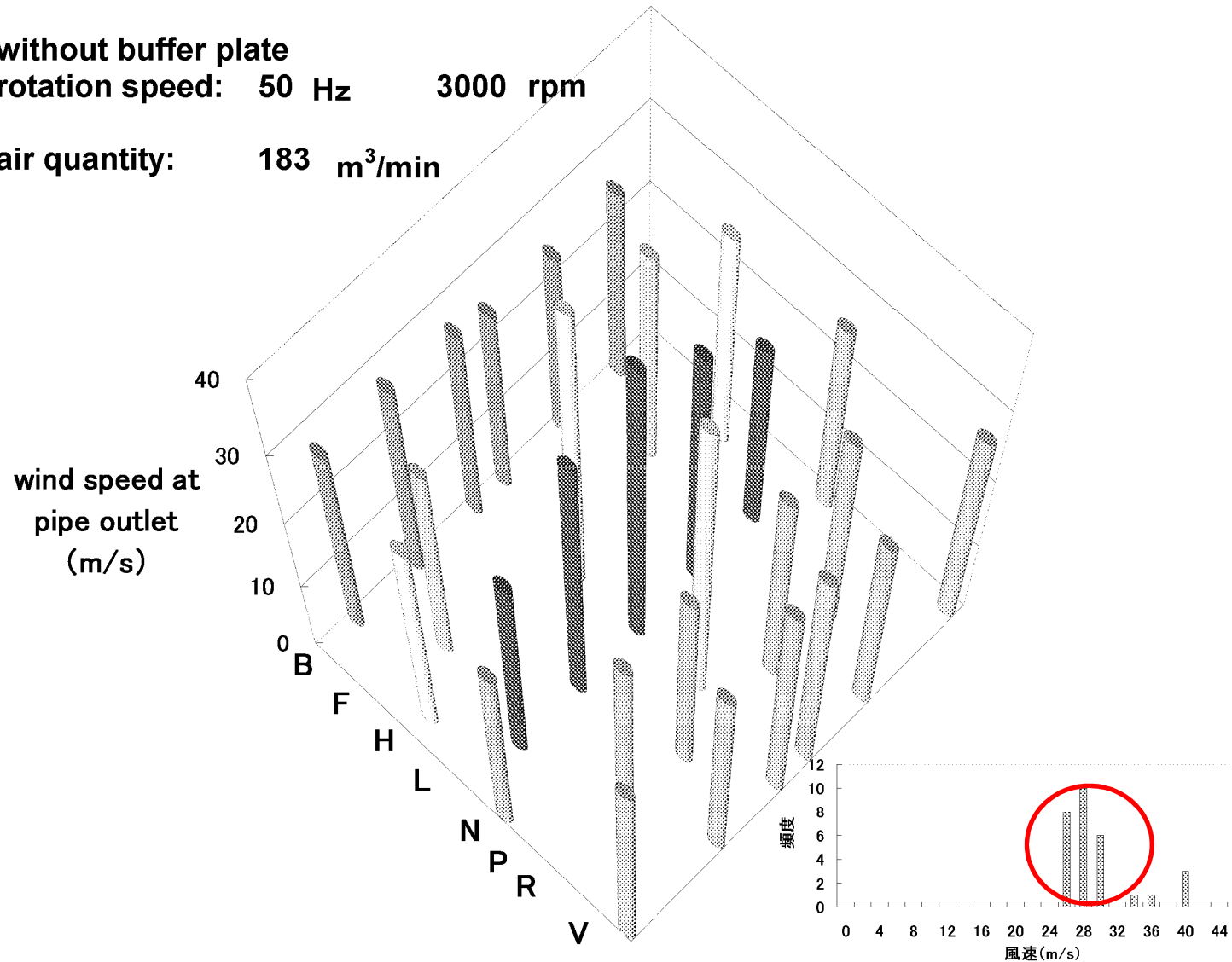


Low Dispersion was Observed

7 . Appendix (No. 3-1)

without buffer plate
rotation speed: 50 Hz 3000 rpm

air quantity: 183 m³/min



Low Dispersion was Observed

HITACHI
Inspire the Next