

**TOSHIBA**

# Steam Turbine and Generator System for Nuclear Power Station

Toshiba has manufactured nuclear turbine generator systems for Boiling Water Reactors (BWRs), Advanced Thermal Reactor (ATR) and Fast Breeder Reactor (FBR) since 1965, when it delivered the first nuclear turbine generator system for the Japan Power Demonstration Reactor (JPDR). Furthermore, Toshiba always builds higher-performance, higher-reliability and lower-cost nuclear turbine generator systems based on its long experience and R&D.

# New Technology and New Systems for Higher Turbine Performance

Toshiba is continuously improving turbine efficiency by using new technologies and systems,

for example by improving the turbine itself (high-performance 3-D blades and long last-stage blades (LSB)), as well as other equipment and systems (reheat cycle and feedwater heater drain pump-up system).

## High-performance 3-D Turbine Blade Enhanced turbine internal efficiency

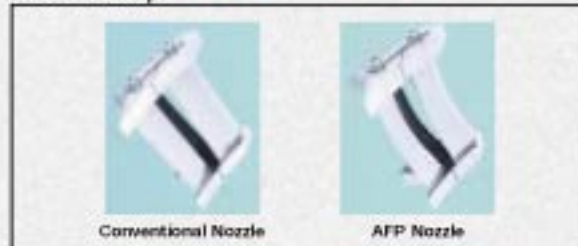
### Features

- AFP (Advanced Flow Pattern) Stage
- Blade loss distribution characterized by blade height. The flow distribution is optimized by changing the nozzle and blade steam path area based on the blade height.
- Secondary flow loss generated on blade root and tip section near wall. Secondary flow loss is prevented by applying a curved 3-D nozzle.

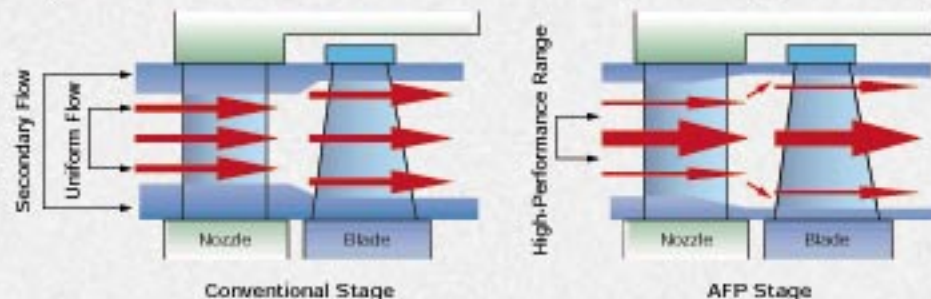
### Loss Distribution of Blade



### Nozzle Shape



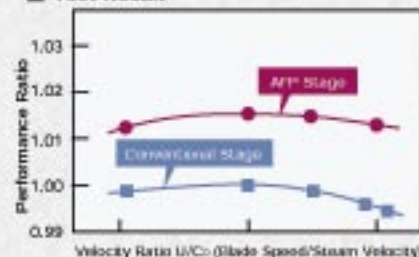
### Optimization of Flow Distribution and Prevention of Secondary Flow Loss by Use of AFP Stage



### Proof

The improved efficiency of the blade profile has been proved by both computerized viscosity analysis and model turbine test

### Test Result



## High-performance Turbine Last-Stage Blade Improvement of Turbine Output

### Features

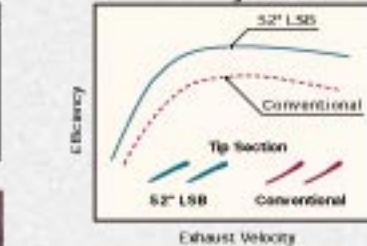
- High-aerodynamic-performance blades with transonic blade profiles
- 3-D Aerodynamic blades achieve high performance in LP stages including LSB by maintaining appropriate flow pattern
- Anti-erosion design based on drain behavior analysis
- World's longest class 52" LSBs for both 1500-rpm and 1800-rpm turbines
- High-reliability based on proven design concepts

### LSB Specifications

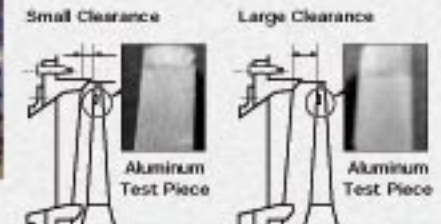
|                      |                | 41" LSB     | 43" LSB     | 52" LSB               |
|----------------------|----------------|-------------|-------------|-----------------------|
| Speed                | r p m          | 1 5 0 0     | 1 8 0 0     | 1 5 0 0 / 1 8 0 0     |
| Length               | m m            | 1 0 4 1 . 4 | 1 0 9 2 . 2 | 1 3 2 0 . 8           |
| PCD                  | m m            | 3 5 0 5 . 2 | 3 3 5 2 . 8 | 4 0 3 3 . 5           |
| Tip Speed            | m / s          | 3 5 7 . 0   | 4 1 8 . 9   | 4 2 0 . 5 / 5 0 4 . 6 |
| Area @ 90° Area      | m <sup>2</sup> | 1 1 . 5     | 1 1 . 5     | 1 5 . 7               |
| Ratio of Wetted Area | %              | 1 0 0       | 1 0 0       | 1 4 6                 |



### 52" Blade Efficiency



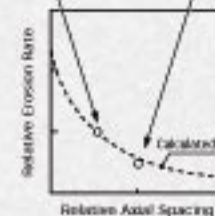
### Erosion Resistance

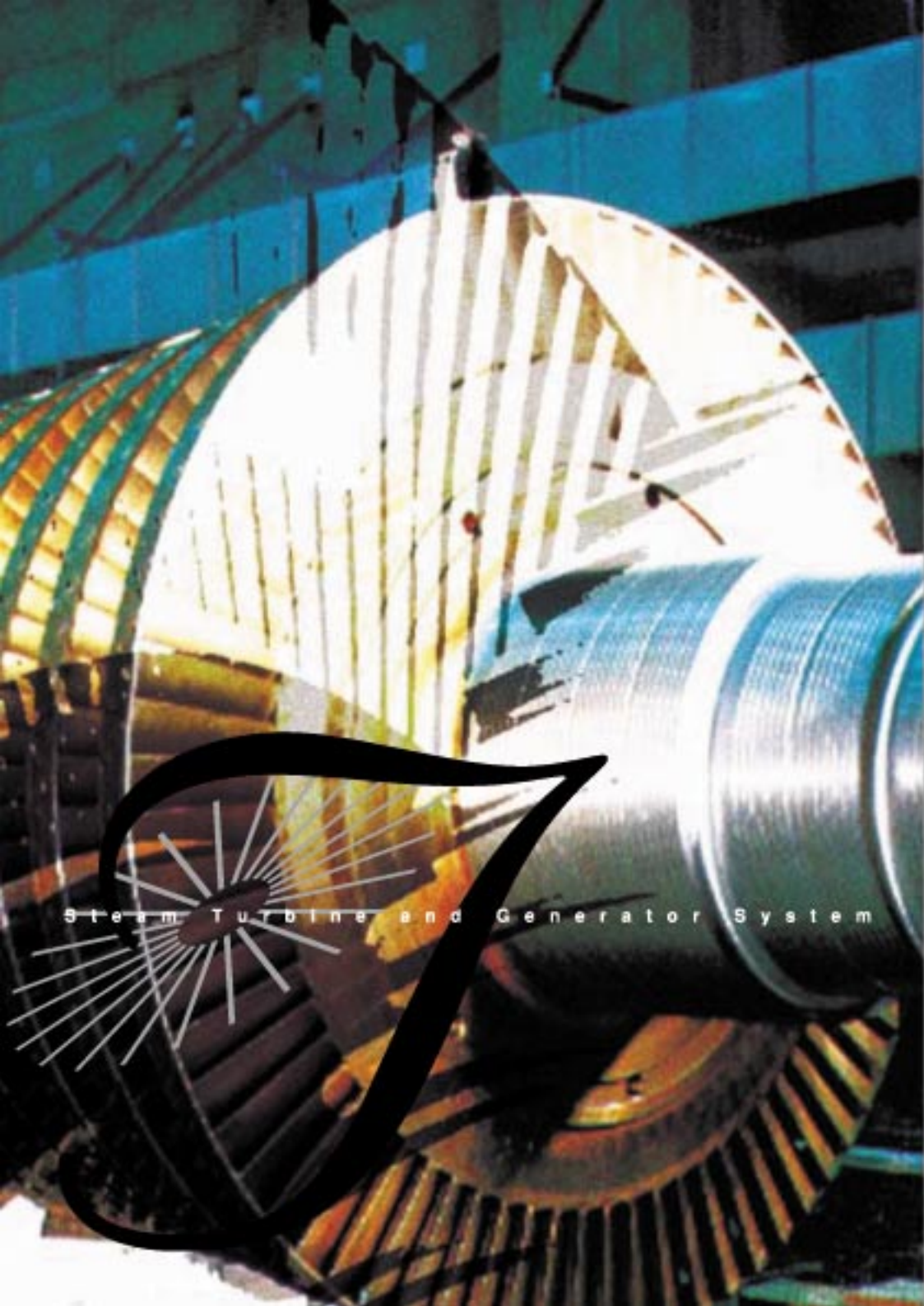


### Turbine Type and Output Range

Toshiba turbines are available in various output ranges by combining high-performance LSBs and casing numbers for every need.

|     |             | (MW)        |             |     |      |      |      |      |      |
|-----|-------------|-------------|-------------|-----|------|------|------|------|------|
|     |             | 400         | 600         | 800 | 1000 | 1200 | 1400 | 1600 | 1800 |
| 5.0 | 104F-41":3C | HP LP LP    | 500-1000MW  |     |      |      |      |      |      |
|     | 104F-52":3C | HP LP LP    | 700-1500MW  |     |      |      |      |      |      |
|     | 106F-41":4C | HP LP LP LP | 800-1500MW  |     |      |      |      |      |      |
|     | 106F-52":4C | HP LP LP LP | 1100-1800MW |     |      |      |      |      |      |
| 4.0 | 104F-43":3C | HP LP LP    | 500-1000MW  |     |      |      |      |      |      |
|     | 104F-52":3C | HP LP LP    | 700-1500MW  |     |      |      |      |      |      |
|     | 106F-43":4C | HP LP LP LP | 800-1500MW  |     |      |      |      |      |      |
|     | 106F-52":4C | HP LP LP LP | 1100-1800MW |     |      |      |      |      |      |





Steam Turbine and Generator System

### Turbine Performance Comparison

