

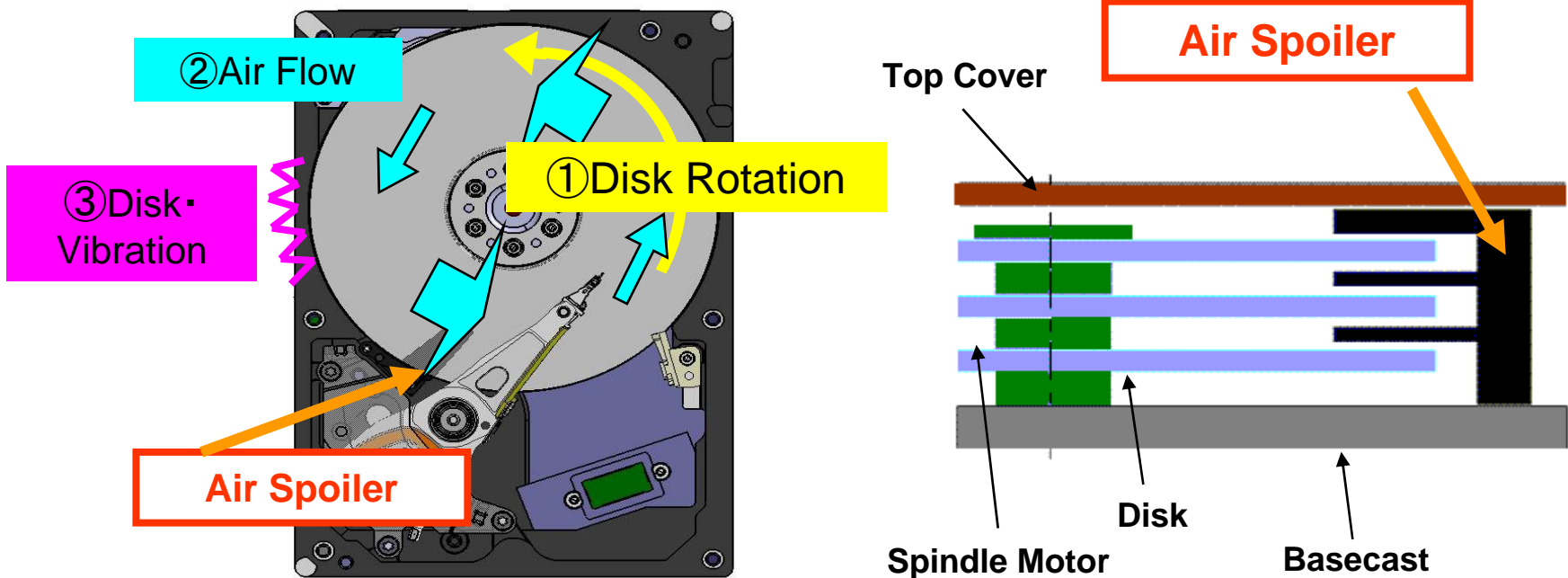
**Introduction of the collaborative activity of KT Method & TRIZ
to improve Hard Disk Drive's Quality and Reliability**

A photograph of a hard disk drive (HDD) is shown in the background, slightly faded. The image shows the internal components of the drive, including the platters and the actuator arm, resting on a light-colored surface.

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C&C HDD Advanced Platform Development**

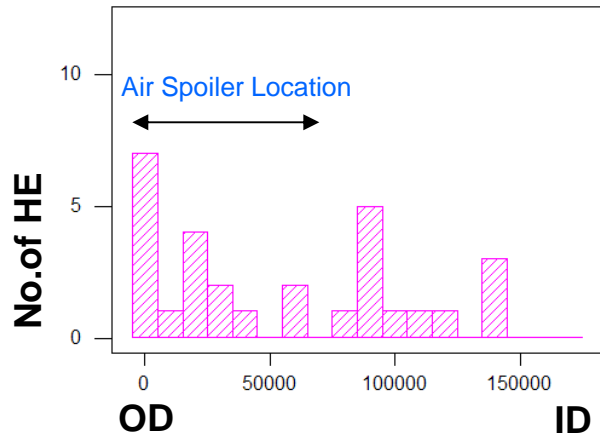
3.5”HDD is using an air spoiler to minimize the disk vibration.



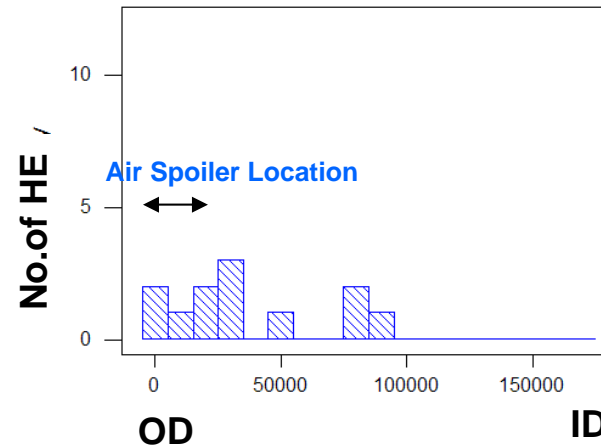
**3.5” HDD’s capacity increase required a bigger air spoiler.
But a bigger air spoiler increases serious data damage on the disk.**

New product “J” which had a bigger air spoiler was required some actions to cover for the disk damage.

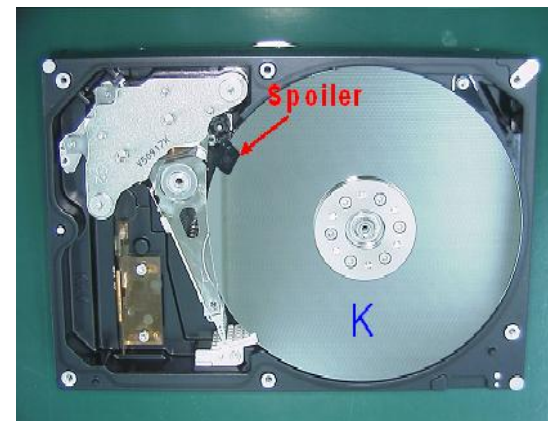
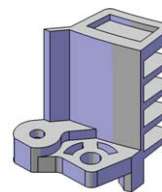
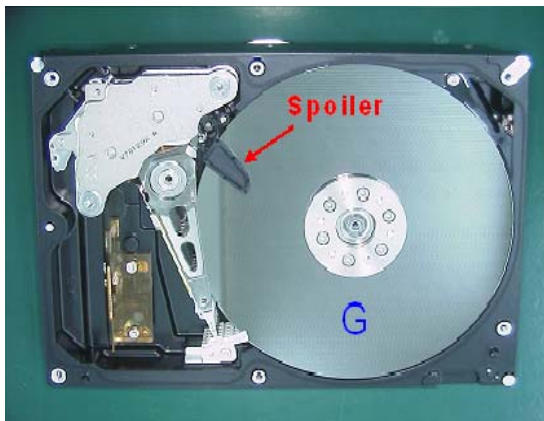
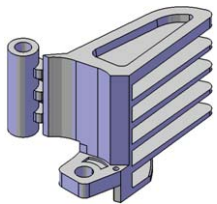
Comparison of Disk damage by contamination (Product "G" & "K")



Product "G" Damage Area



Product "K" Damage Area



Most of all disk damage were under a air spoiler.

3-1. Problem Analysis of OD Scratch 1/3

問題の明確化 / 問題の明確化				
State the Problem				区別点と変化の確認
Identify the root cause of the data damage occurred on Outside Data Zone (OD) area of new 3.5" HDD				Distinction
問題の明確化	What is wrong in the way the object looks, sounds, feels, smells		What is NOT wrong this time, even though it is related, or was wrong, at other times	
	IS		IS NOT	Peculiarities and differences about the "IS" and "IS NOT" columns
WHAT(何に)				
対象は?	New 3.5" HDD	1	Old 3.5" HDD	Areal Density Increase
		2	New 2.5" HDD	Aluminum Disk, Air Spoiler, Higher RPM
差異(欠陥)は?	Scratch Increase @OD	3	No Scratch @ID	Higher RPM
	Spiral Scratch @OD	4	Head Crush @OD	Head treads on contamination @OD
WHERE(どこで)				
地理的な場所は?	OD & MD area	5	ID area	Higher relative speed
対象のどの部分で?	Surface with Air Spoiler	6		Crosscurrent on the disk
	Under Air Spoiler	7	Under Actuator	

3-2. Problem Analysis of OD Scratch 2/3

問題の明細化	起きた事実		起きてもよさそうなのに起きていない事実	Distinction
	IS		IS NOT	
WHEN(いつ)				
<i>最初に起きたのはいつからか?</i>	New 3.5" HDD	8		Areal Density Increase
<i>どのような場合に起きたのか?</i>	Just after POR	9		Contamination on disk Easily trend on the big Contamination
	After Load/Unload	10		
EXTENT(どの程度)				
<i>どれくらいの数量か?</i>	5 fail out of 1,000 HDDs	11		
<i>どのような傾向か?</i>	Increase	12	Decrease	

Assumed Cause based on Distinction	Test by IS/IS Not
<p>Sensitivity of Media against scratch is getting higher and higher due to capacity increase. And the relative speed between head and disk is highest at OD area.</p>	<p>1 2 3 4 5 6 7 8 9 10 11 12 ○ ○ ○ △ ○ × ○ ○ ○ × ○ ○</p>
<p>The air spoiler create the crosscurrent (Karman voltex). This crosscurrent accelerates nano-particle to accrete the disk. (MPC?)</p>	<p>1 2 3 4 5 6 7 8 9 10 11 12 ○ ○ ○ ○ ○ ○ △ ○ ○ ○ ○ ○</p>
<p>Some asperities remained on the disk. Some of them escaped from the disk MFG process, some of them were generated by Cobalt migration on the disk.</p>	<p>1 2 3 4 5 6 7 8 9 10 11 12 ○ △ ○ ○ ○ × ○ ○ ○ ○ ○ ○</p>

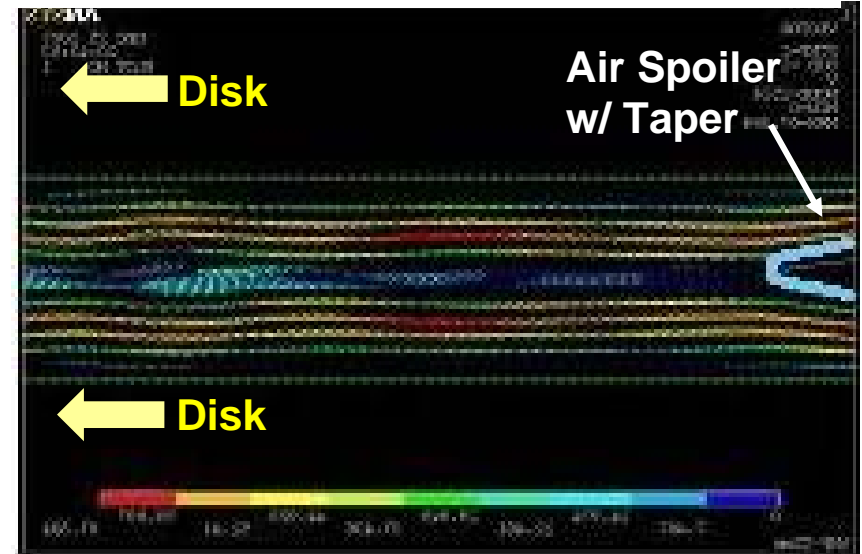
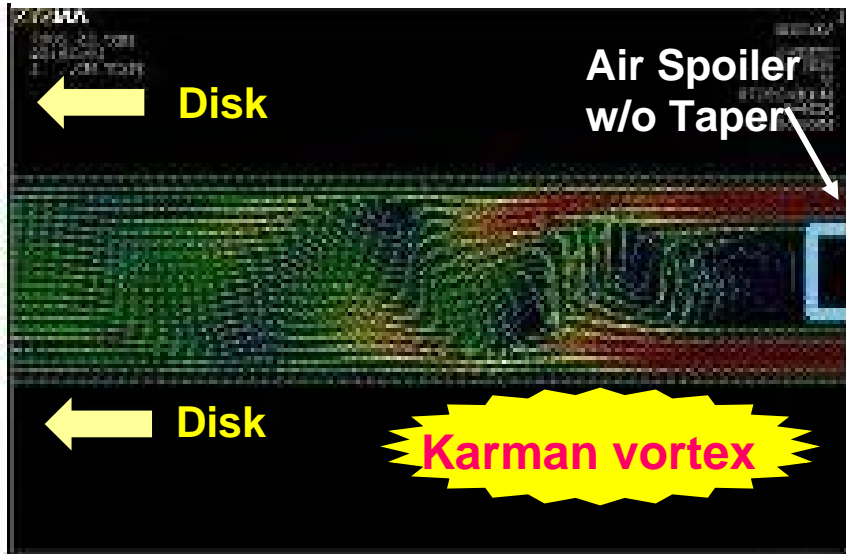
If higher recording density or asperity on the disk is root cause, they can not explain why many HE were under the air spoiler. HE increased area depends on the air spoiler, but it does not depend on the actuator. They are clearly conflicting.

Why an air spoiler accelerates accrete contamination to the disk?

Focused attention on Air Spoiler's Shape

■ Two-dimensional Fluid Analysis (ANSYS)

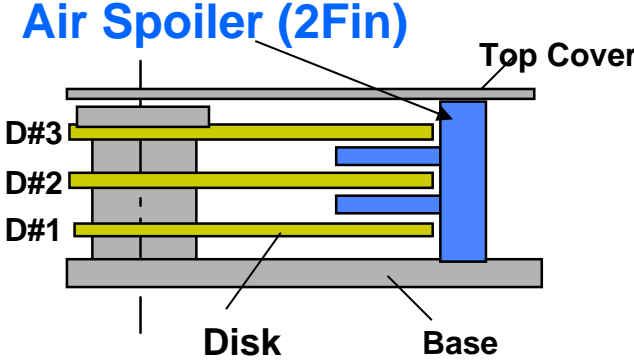
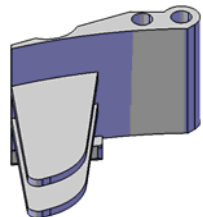


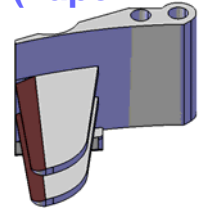
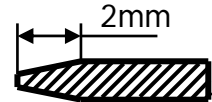
Disk Rotation Speed : 30m/s (at 40mm from the center of Disk)



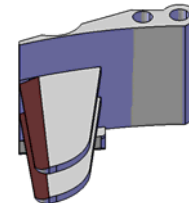
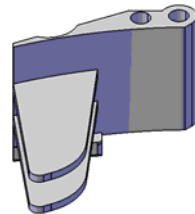
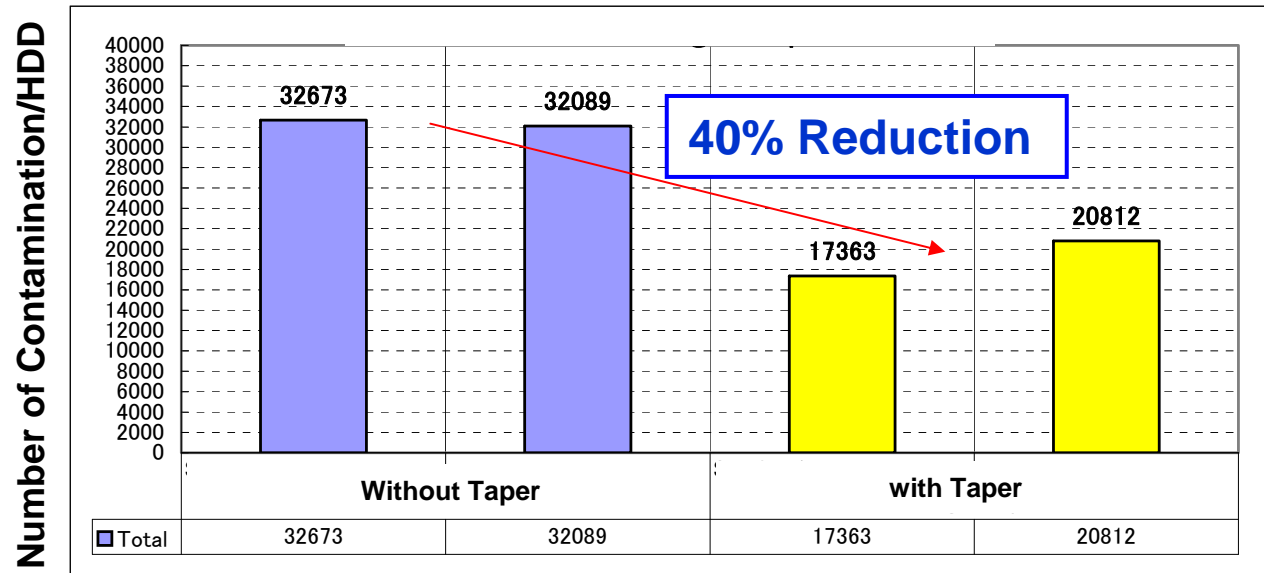
An air spoiler without taper makes Karman vortex and accelerate to accrete the contamination on the disk. But an air spoiler with taper reduces Karman vortex and the contamination on the disk.

Particle Injection Test to confirm the simulation result

■ Air Spoiler used for Particle Injection Test

3 Disk Model	Air Spoiler	Cross Section
<p>Air Spoiler (2Fin)</p> 	<p>① 2 fin type</p> 	<p>without Taper</p> 
	<p>② 2 fin type (Taper 2mm)</p> 	<p>with Taper</p> 

■ Measurement Result of Contamination on the disk

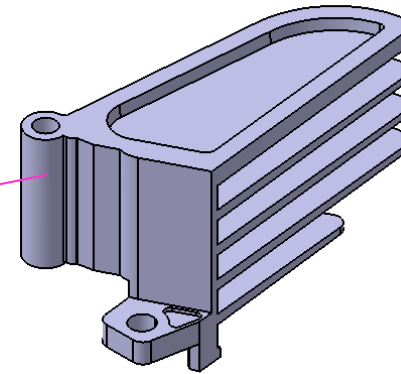
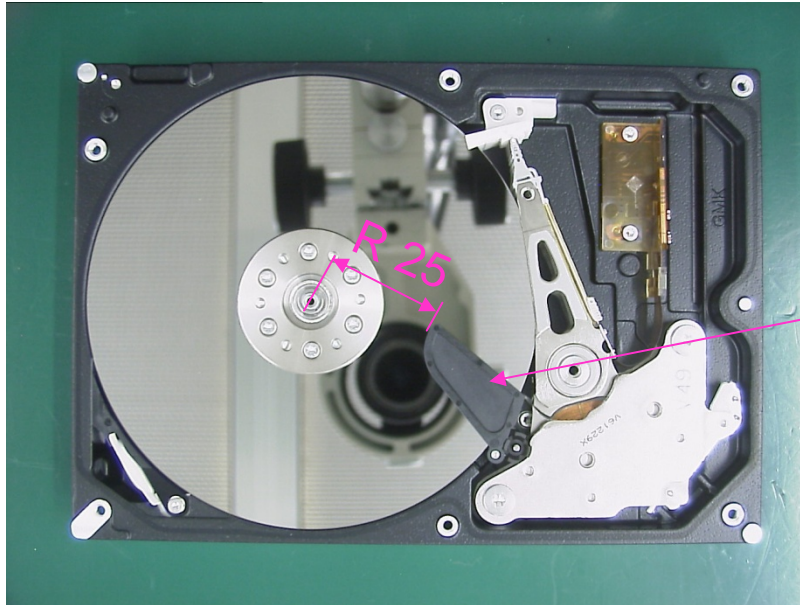


It was confirmed that the air spoiler with taper could contain the Karman vortex and decrease the contamination on the disk.

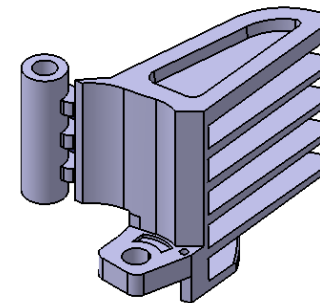
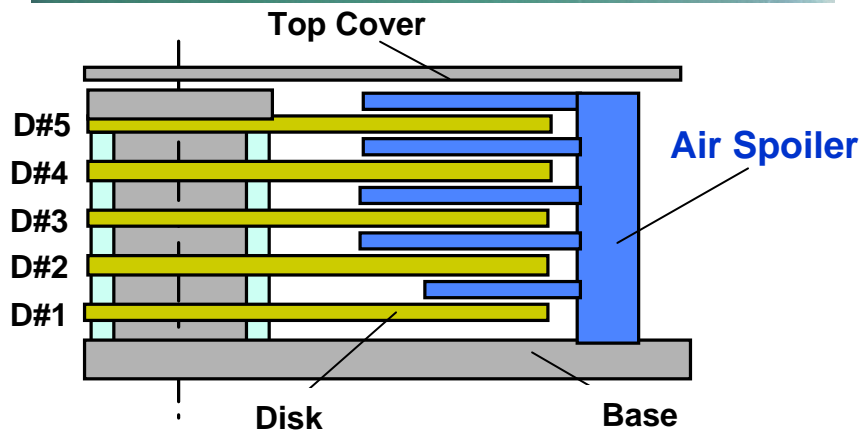
6. Jumboizing Air Spoiler

Jumboizing Air Spoiler to improve NRRO for new product

→ Concern on Contamination increase



Air Spoiler "J"



Air Spoiler "G"

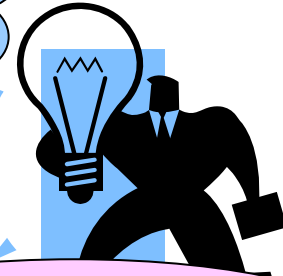
7. Break through "PSYCHOLOGICAL INERTIA"



Head/Disk engineer

Hey, reduce contamination near spoiler on the disk.

Because we need higher areal density than previous model



What is truly needed?



Mechanics engineer

*Not Air Flow!
It's another Physical Force!
Other ways we have!*



*Karman Vortex,
Karman Vortex,
Karman Vortex,
Karman Vortex,
...
Can do nothing about....*

TRIZ methodology is based on breakthrough of "Psychological inertia"

8. Correspondence between HDD's and TRIZ parameter

Key Word of HDD parameter	TRIZ 48 Parameters
Bit length on the Disk	Length of stationary object (4)
Error Rate	Loss of Time (26)、Loss of Information (28)
Seek Time	Duration of Action of Moving Object (12)
Weight Saving	Weight of Stationary Object (2)
Sound	Noise (29)
Thermal Stability	Stability (21)
Track Per Inch	Information (11)
Reliability	Reliability (35)
Write Fault Frequency	Loss of Information (28)、Loss of Time (26)
Power Consumption	Loss of Energy (27)
Positioning Accuracy	Reliability (35)
Rotational Waiting Time	Loss of Time (26)
Cost	Productivity (44)
Radiation	Temperature (22)
Detectability of media defect	Ability of Detect/Measure (47)
Test Time	Loss of Time (26)、Productivity (44)

- Jumboizing the air spoiler accelerate the data damage at out side area of the media by the media scratch.
- Contradiction Matrix from Inventive Principles

– 4 x 28 (Length of Stationary Object/Loss of Information)

- 28: **Mechanics Substitution**
- 24: **Intermediary**
- 3: **Local Quality**
- 13: **“The Other Way Around”**

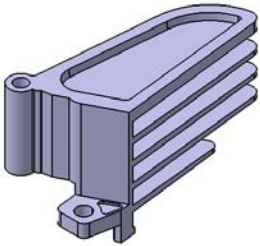

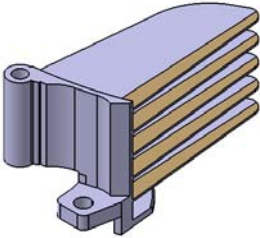
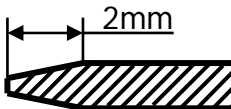
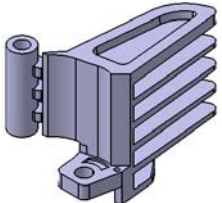

Introduce electric, magnetic or electromagnetic fields to interact with an object .
=> Conductive Air Spoiler

– 4 x 35 (Length of Stationary Object/Reliability)

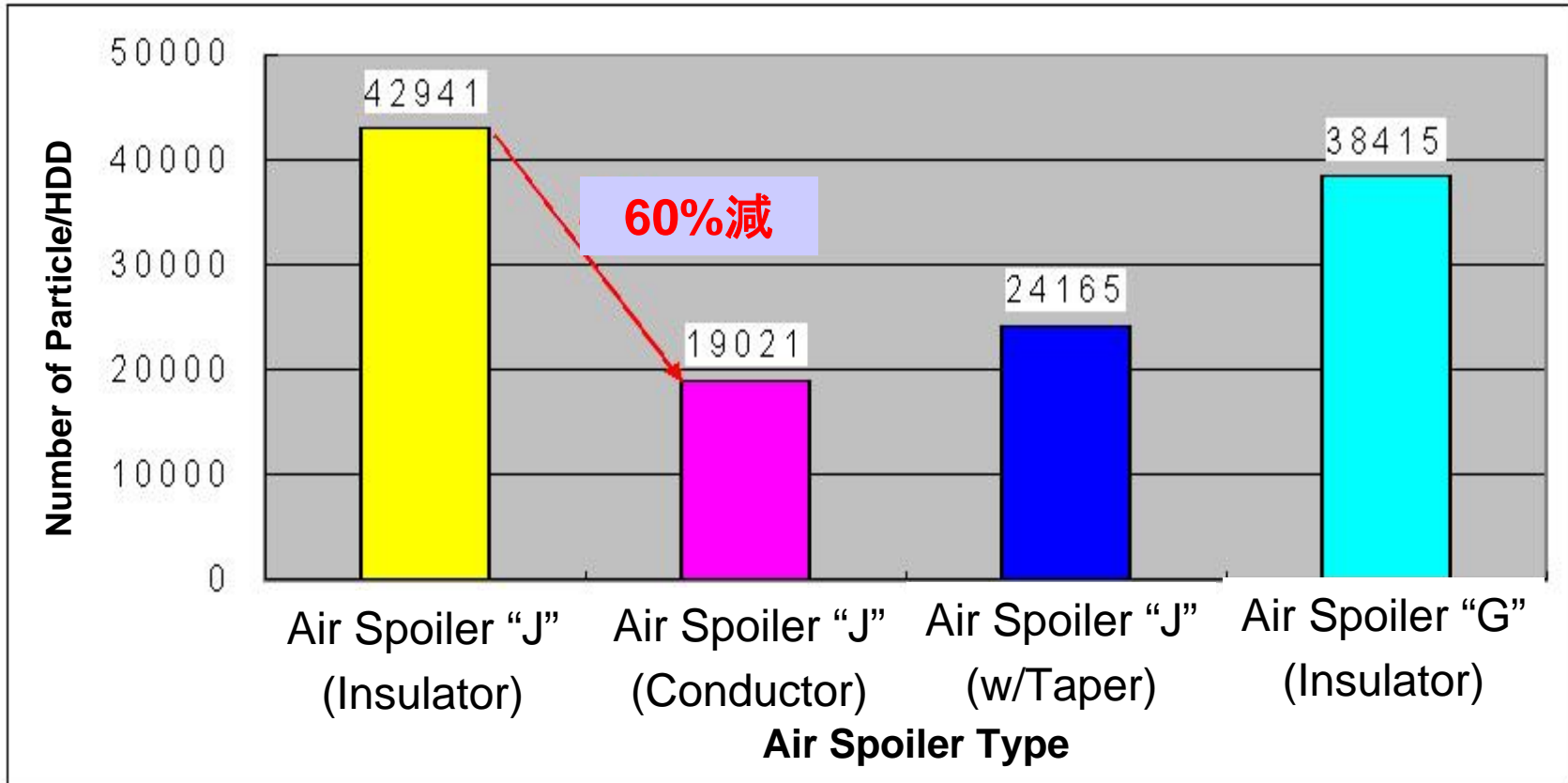
- 35: **Parameter Changes**
- 31: **Porous Materials**
- 29: **Pneumatics And Hydraulics**
- 17: **Another Dimension**

Enable each part of a system to function in locally optimised conditions.
=> With Taper

■ Air Spoiler used for Particle Injection Test

Figure	Model	Material	Surface Resistance	Cross Section
	J	Polycarbonate	1 E16 (Insulator)	w/o Taper 
		Plastic with Carbon fiber	1 E1~E3 (Conductor)	
	J w/Taper	Polycarbonate	1 E16 (Insulator)	w/Taper 
	G	Polycarbonate	1 E16 (Insulator)	w/o Taper 

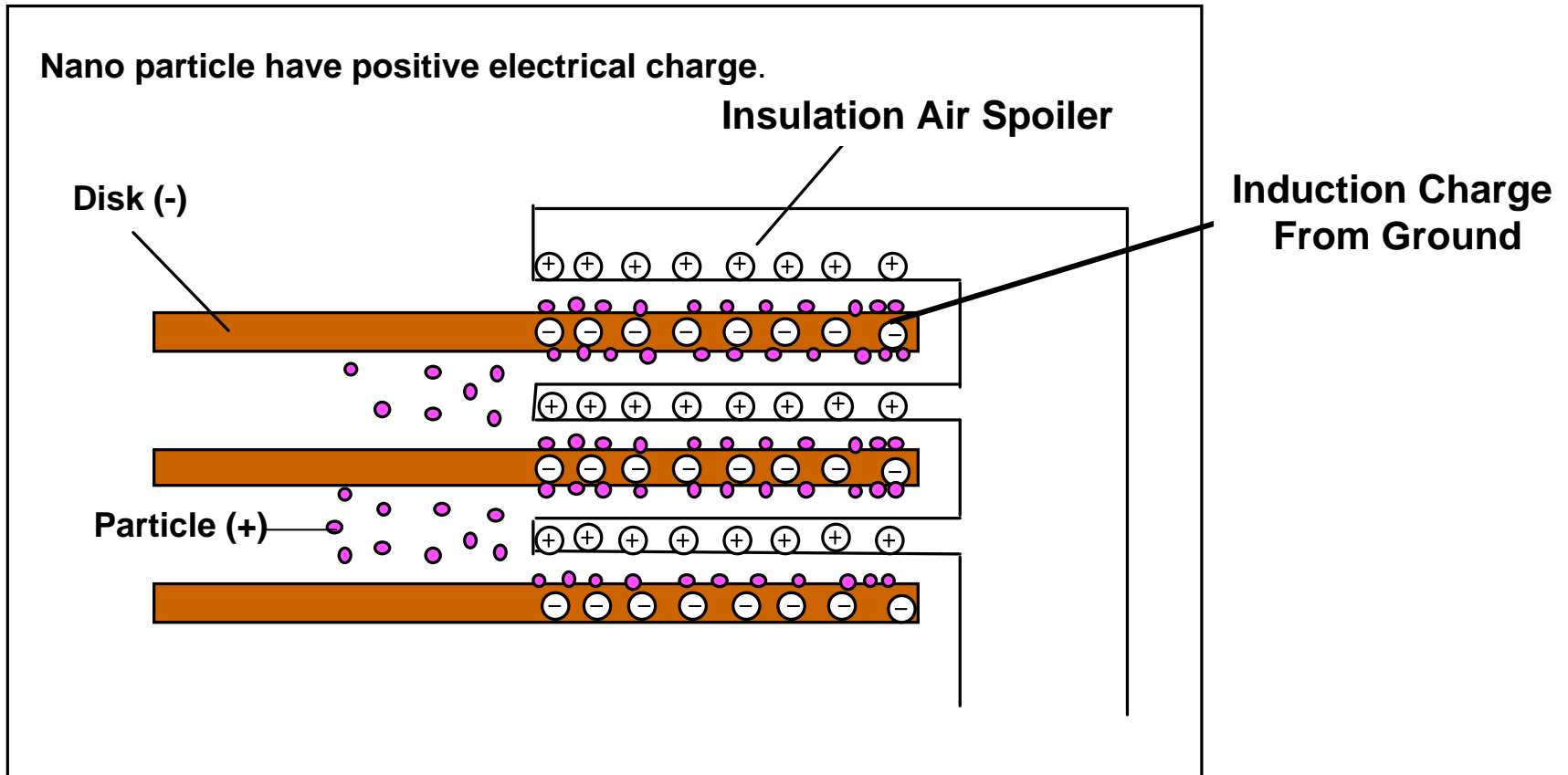
■ Measurement Result of Particle



Significant Improvement of Particle Reduction by Conductive Air Spoiler

Why the conductive air spoiler can reduce the particle accretion?

■ Mechanism of Particle Accretion on the Disk by Static Electrical Charge



Nano-Particles with positive electrical charge gravitate toward the disk with negative electrical charge induced by the insulation air spoiler with positive electrical charge.