

# Oracle Backup and Recovery

## Understand Full and Incremental Backup

### Lo, L1, Differential, Cumulative

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[https://www.youtube.com/channel/UCCGTnI9vvF\\_ETMhGUXGdFWw](https://www.youtube.com/channel/UCCGTnI9vvF_ETMhGUXGdFWw)

## 1. FULL BACKUP vs INCREMENTAL BACKUP

### Full Backup

A full backup is a complete backup of all used data blocks in the database. It includes every block that has ever been written to, skipping only blocks that have never been used. A full backup cannot be part of an incremental backup strategy and cannot serve as a parent for incremental backups.

#### Key Characteristics:

- Backs up ALL used data blocks
- Skips only unused (never-written) blocks
- Cannot be used as base for Level 1 incremental backups
- Standalone backup not tied to any incremental strategy

#### Command to Take Full Backup:

RMAN> BACKUP DATABASE;

#### Example Command with Format:

RMAN> BACKUP DATABASE FORMAT '/backup/full\_%d\_%T\_%s\_%p.bkp';

## 2. INCREMENTAL BACKUP LEVELS

### Incremental Backup

Incremental backups back up only data blocks that have changed since a previous backup. There are two levels: Level 0 (L0) and Level 1 (L1).

#### Level 0 Incremental Backup (L0)

A level 0 incremental backup copies all blocks containing data and serves as the base for subsequent incremental backups. The only difference between a level 0 incremental backup and a full backup is that a full backup is never included in an incremental strategy.

#### Key Characteristics:

- Physically identical to a full backup in content
- Backs up ALL data blocks
- Serves as the base/parent for all Level 1 backups
- Can be used in incremental backup strategy
- Must exist before taking any Level 1 backups

#### Command to Take Level 0 Backup:

RMAN> BACKUP INCREMENTAL LEVEL 0 DATABASE;

#### Example with Format and Compression:

RMAN> BACKUP INCREMENTAL LEVEL 0 DATABASE FORMAT '/backup/Lo\_%d\_%T\_%s\_%p.bkp';

## Level 1 Incremental Backup (L1)

A level 1 incremental backup includes only those blocks that have been changed since a previous backup. A level 1 incremental backup can be either differential or cumulative.

### Key Characteristics:

- Backs up only CHANGED blocks since last backup
- Much smaller than Level 0
- Faster to complete than Level 0
- Can be differential (default) or cumulative
- Cannot exist without a Level 0 base

## 3. DIFFERENTIAL INCREMENTAL BACKUPS (Level 1 Differential)

A differential incremental backup backs up all blocks changed after the most recent incremental backup at level 1 or level 0. RMAN determines which level 1 backup occurred most recently and backs up all blocks modified after that backup. If no level 1 is available, RMAN copies all blocks changed since the level 0 backup.

### How It Works:

- Backs up blocks changed since the MOST RECENT backup (L1 or L0)
- Default type of incremental backup
- Each backup is smaller and faster than cumulative
- Requires applying multiple backups in sequence during recovery

### Example Scenario:

#### Timeline:

Sunday 5:00 PM	Level 0 Backup (Full backup of all blocks)
Monday 5:00 PM	Level 1 Differential (Changes since Sunday)
Tuesday 5:00 PM	Level 1 Differential (Changes since Monday)
Wednesday 5:00 PM	Level 1 Differential (Changes since Tuesday)
Thursday 5:00 PM	Level 1 Differential (Changes since Wednesday)

### Blocks Backed Up:

- **Sunday L0:** All 1,000,000 blocks (e.g., database is 10 GB)
- **Monday L1 Diff:** 50,000 blocks changed (changes since Sunday)
- **Tuesday L1 Diff:** 40,000 blocks changed (changes since Monday)
- **Wednesday L1 Diff:** 35,000 blocks changed (changes since Tuesday)
- **Thursday L1 Diff:** 45,000 blocks changed (changes since Wednesday)

**Total Backup Storage:** ~1,170,000 blocks

**Recovery Scenario (if disaster occurs Friday 3 PM):** You must restore in sequence:

1. Restore from Sunday L0 backup
2. Apply Monday L1 Differential
3. Apply Tuesday L1 Differential
4. Apply Wednesday L1 Differential
5. Apply Thursday L1 Differential
6. Apply archived redo logs from Thursday 2:45 PM to Friday 3:00 PM

## Commands:

```
# Connect to RMAN
RMAN> CONNECT TARGET /
# Take Level 0 backup on Sunday
RMAN> BACKUP INCREMENTAL LEVEL 0 DATABASE FORMAT '/backup/Lo_%d_%T_%s_%p.bkp' TAG
'sunday_L0';
# Take Level 1 Differential backup Monday
RMAN> BACKUP INCREMENTAL LEVEL 1 DATABASE FORMAT '/backup/L1_diff_%d_%T_%s_%p.bkp' TAG
'monday_L1_diff';
# Take Level 1 Differential backup Tuesday
RMAN> BACKUP INCREMENTAL LEVEL 1 DATABASE FORMAT '/backup/L1_diff_%d_%T_%s_%p.bkp' TAG
'tuesday_L1_diff';
# Take Level 1 Differential backup on specific tablespace
RMAN> BACKUP INCREMENTAL LEVEL 1 TABLESPACE USERS FORMAT
'/backup/L1_diff_%d_%T_%s_%p.bkp';
# Take Level 1 Differential backup on specific datafile
RMAN> BACKUP INCREMENTAL LEVEL 1 DATAFILE 4 FORMAT '/backup/L1_diff_%d_%T_%s_%p.bkp';
```

## 4. CUMULATIVE INCREMENTAL BACKUPS (Level 1 Cumulative)

A cumulative level 1 backup backs up all the blocks used since the most recent level 0 incremental backup.

### How It Works:

- Backs up ALL blocks changed since the MOST RECENT LEVEL 0 ONLY
- Ignores other Level 1 backups
- Larger and slower than differential
- Simplifies recovery (only need L0 + one L1)
- Preferred when recovery time is critical

### Example Scenario: Timeline:

Sunday 5:00 PM	Level 0 Backup (Full backup of all blocks)
Monday 5:00 PM	Level 1 Cumulative (All changes since Sunday L0)
Tuesday 5:00 PM	Level 1 Cumulative (All changes since Sunday L0)
Wednesday 5:00 PM	Level 1 Cumulative (All changes since Sunday L0)
Thursday 5:00 PM	Level 1 Cumulative (All changes since Sunday L0)

### Blocks Backed Up:

- **Sunday L0:** All 1,000,000 blocks (e.g., database is 10 GB)
- **Monday L1 Cum:** 50,000 blocks changed (changes since Sunday)
- **Tuesday L1 Cum:** 85,000 blocks total changed (includes Monday's changes + Tuesday's new changes)
- **Wednesday L1 Cum:** 125,000 blocks total changed (includes all changes since Sunday through Wednesday)
- **Thursday L1 Cum:** 170,000 blocks total changed (includes all changes since Sunday through Thursday)

**Total Backup Storage:** ~1,430,000 blocks (more than differential)

**Recovery Scenario (if disaster occurs Friday 3 PM):** You only need to restore in order:

1. Restore from Sunday L0 backup
2. Apply Thursday L1 Cumulative (contains ALL changes since Sunday)
3. Apply archived redo logs from Thursday 2:45 PM to Friday 3:00 PM

**Advantage:** Only ONE L1 backup to apply instead of multiple

## Commands:

```
# Connect to RMAN
RMAN> CONNECT TARGET /
# Take Level 0 backup on Sunday
RMAN> BACKUP INCREMENTAL LEVEL 0 DATABASE FORMAT '/backup/Lo_%d_%T_%s_%p.bkp' TAG
'sunday_L0';
# Take Level 1 Cumulative backup Monday
RMAN> BACKUP INCREMENTAL LEVEL 1 CUMULATIVE DATABASE FORMAT
'/backup/L1_cum_%d_%T_%s_%p.bkp' TAG 'monday_L1_cum';
# Take Level 1 Cumulative backup Tuesday
RMAN> BACKUP INCREMENTAL LEVEL 1 CUMULATIVE DATABASE FORMAT
'/backup/L1_cum_%d_%T_%s_%p.bkp' TAG 'tuesday_L1_cum';
# Take Level 1 Cumulative backup on specific tablespace
RMAN> BACKUP INCREMENTAL LEVEL 1 CUMULATIVE TABLESPACE USERS FORMAT
'/backup/L1_cum_%d_%T_%s_%p.bkp';
# Take Level 1 Cumulative backup on specific datafile
RMAN> BACKUP INCREMENTAL LEVEL 1 CUMULATIVE DATAFILE 5 FORMAT
'/backup/L1_cum_%d_%T_%s_%p.bkp';
```

## 5. COMPARISON: DIFFERENTIAL vs CUMULATIVE

Aspect	Differential L1	Cumulative L1
Backs up blocks changed since	Last L0 or L1	Last L0 ONLY
Backup Size	Smaller (default)	Larger
Backup Time	Faster	Slower
Storage Required	Less storage	More storage
Recovery Time	Longer (apply multiple L1s)	Shorter (apply only one L1)
Use Case	When disk space is limited	When fast recovery is critical
Recovery Process	Must apply all L1s sequentially	Apply only latest L1 + L0
Number of L1s to apply	Multiple (Monday→Tuesday→etc)	Only one (latest)

## 6. WHEN TO USE EACH TYPE

### Use Differential Incremental When:

- You have limited disk space for backup storage
- Faster backup execution is needed
- Recovery time is not critical
- You want minimal storage overhead

### Use Cumulative Incremental When:

- Recovery time is more important than disk space, because during recovery each differential backup must be applied in succession. Use cumulative incremental backups instead of differential if enough disk space is available.
- Fast recovery from failures is required
- You have sufficient disk space
- Simplicity of recovery process is important

## 7. COMPLETE BACKUP STRATEGY EXAMPLE

### Weekly Backup Plan

SUNDAY 11:00 PM

Level 0 Backup (Full):

```
RMAN> BACKUP INCREMENTAL LEVEL 0 DATABASE FORMAT '/backup/Lo_%d_%T_%s_%p.bkp' TAG 'weekly_L0';
```

MONDAY TO FRIDAY 12:00 PM (Differential)

Level 1 Differential Backups:

```
RMAN> BACKUP INCREMENTAL LEVEL 1 DATABASE FORMAT '/backup/L1_diff_%d_%T_%s_%p.bkp' TAG 'daily_L1_diff';
```

OR

MONDAY TO FRIDAY 12:00 PM (Cumulative)

Level 1 Cumulative Backups:

```
RMAN> BACKUP INCREMENTAL LEVEL 1 CUMULATIVE DATABASE FORMAT '/backup/L1_cum_%d_%T_%s_%p.bkp' TAG 'daily_L1_cum';
```

HOURLY (Every hour)

Archived Redo Log Backup:

```
RMAN> BACKUP ARCHIVELOG ALL FORMAT '/backup/arch_%d_%T_%s_%p.bkp' DELETE INPUT;
```

### Recovery from Friday 3 PM Failure

#### Using Differential (More steps):

```
RMAN> RESTORE DATABASE FROM TAG 'weekly_L0';
RMAN> RECOVER DATABASE FROM TAG 'daily_L1_diff' OF MONDAY;
RMAN> RECOVER DATABASE FROM TAG 'daily_L1_diff' OF TUESDAY;
RMAN> RECOVER DATABASE FROM TAG 'daily_L1_diff' OF WEDNESDAY;
RMAN> RECOVER DATABASE FROM TAG 'daily_L1_diff' OF THURSDAY;
RMAN> RECOVER DATABASE FROM TAG 'daily_L1_diff' OF FRIDAY;
RMAN> RECOVER DATABASE USING BACKUP LOCATION '/backup/arch_*.bkp';
RMAN> ALTER DATABASE OPEN RESETLOGS;
```

#### Using Cumulative (Fewer steps):

```
RMAN> RESTORE DATABASE FROM TAG 'weekly_L0';
RMAN> RECOVER DATABASE FROM TAG 'daily_L1_cum' OF FRIDAY;
RMAN> RECOVER DATABASE USING BACKUP LOCATION '/backup/arch_*.bkp';
RMAN> ALTER DATABASE OPEN RESETLOGS;
```

## 8. MONITORING AND MANAGEMENT

### Check Backup Information

# View all backup information

```
RMAN> LIST BACKUP;
```

# View incremental backups

```
RMAN> LIST BACKUP OF INCREMENTAL LEVEL 0;
```

```
RMAN> LIST BACKUP OF INCREMENTAL LEVEL 1;
```

# View backup by specific tag

```
RMAN> LIST BACKUP OF DATABASE TAG 'weekly_L0';
```

```
# View datafile backup information
```

```
SQL> SELECT FILE#, INCREMENTAL_LEVEL, COMPLETION_TIME, BLOCKS, DATAFILE_BLOCKS
  FROM V$BACKUP_DATAFILE
 WHERE INCREMENTAL_LEVEL > 0
   AND BLOCKS / DATAFILE_BLOCKS > .5
 ORDER BY COMPLETION_TIME;
```

## When to Take New Level 0 Backup

When the most recent level 1 backup is about half of the size of the base level 0 backup, take a new level 0. For example, if you only create level 1 cumulative backups, then when the most recent level 1 backup is about half of the size of the base level 0 backup, take a new level 0.

### Example Threshold:

- If Level 0 = 10 GB
- If most recent L1  $\geq$  5 GB
- Then take a new Level 0 backup

## 9. RMAN CONFIGURATION FOR BACKUPS

### Configure RMAN Before Taking Backups

```
# Connect to RMAN
```

```
RMAN> CONNECT TARGET /
```

```
# Enable control file autobackup
```

```
RMAN> CONFIGURE CONTROLFILE AUTOBACKUP ON;
```

```
# Set control file autobackup format
```

```
RMAN> CONFIGURE CONTROLFILE AUTOBACKUP FORMAT FOR DEVICE TYPE DISK
```

```
  TO '/backup/controlfile/%F';
```

```
# Enable backup optimization (skip unchanged files)
```

```
RMAN> CONFIGURE BACKUP OPTIMIZATION ON;
```

```
# Configure multiple backup channels (parallel backup)
```

```
RMAN> CONFIGURE DEVICE TYPE DISK PARALLELIZATION 4;
```

```
# Set backup piece size (unlimited)
```

```
RMAN> CONFIGURE CHANNEL DEVICE TYPE DISK
```

```
  MAXPIECESIZE UNLIMITED;
```

```
# View current configuration
```

```
RMAN> SHOW ALL;
```

## Key Takeaways

1. **Full Backup** = Standalone, complete backup not part of incremental strategy
2. **Level 0 (L0)** = Incremental base (like full backup) but can have L1 children
3. **Level 1 Differential** = Changes since last L0 or L1 (smaller, faster, multiple to apply)
4. **Level 1 Cumulative** = Changes since last L0 only (larger, but only one to apply)
5. **Backup Strategy** = L0 weekly + L1 daily + Archive logs hourly
6. **Recovery** = Faster with cumulative, but more storage; faster backup with differential, but slower recovery

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