Chemical Equipment Visualizer

Professional Project Documentation

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Executive Summary

The **Chemical Equipment Visualizer** is an enterprise-grade, web-based analytics dashboard designed specifically for the chemical and industrial engineering sectors. The application enables organizations to upload, analyze, and visualize equipment data with professional-grade analytics, interactive charts, and comprehensive reporting capabilities.

Key Value Propositions

- **Rapid Data Analysis:** Process and analyze equipment data in seconds
- **Professional Visualizations:** Industry-grade charts and analytics dashboards
- **Data Export:** Generate PDF reports and CSV exports for stakeholder communication
- **Secure Access:** Enterprise authentication with session management
- **User-Friendly Interface:** Intuitive design with minimal training required
- **Scalable Architecture:** Built to handle growing data volumes and user bases

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Project Overview

Purpose

The Chemical Equipment Visualizer addresses the critical need for real-time equipment monitoring and data analysis in the chemical manufacturing sector. It transforms raw equipment data into actionable insights through interactive visualizations, statistical analysis, and comprehensive reporting tools.

Target Users

- **Operations Managers:** Monitor equipment performance and KPIs
- **Plant Engineers:** Analyze equipment data for optimization
- **Quality Assurance Teams:** Generate compliance reports
- **Management & Executives:** Access high-level analytics and trends

Business Objectives

1. Reduce time spent on manual data analysis by 80%
2. Enable data-driven decision making across the organization
3. Provide professional reporting capabilities for stakeholder communication
4. Improve equipment monitoring and performance tracking
5. Facilitate regulatory compliance and documentation

Architecture & Technology Stack

System Architecture

■■■
■■■■

■ CLIENT TIER (Web Browser) ■

■■■
■■■■

■ React 19.2.0 + TypeScript 5.9 ■

■ • Authentication & Session Management ■

■ • Data Upload & Validation ■

■ • Interactive Dashboard & Charts ■

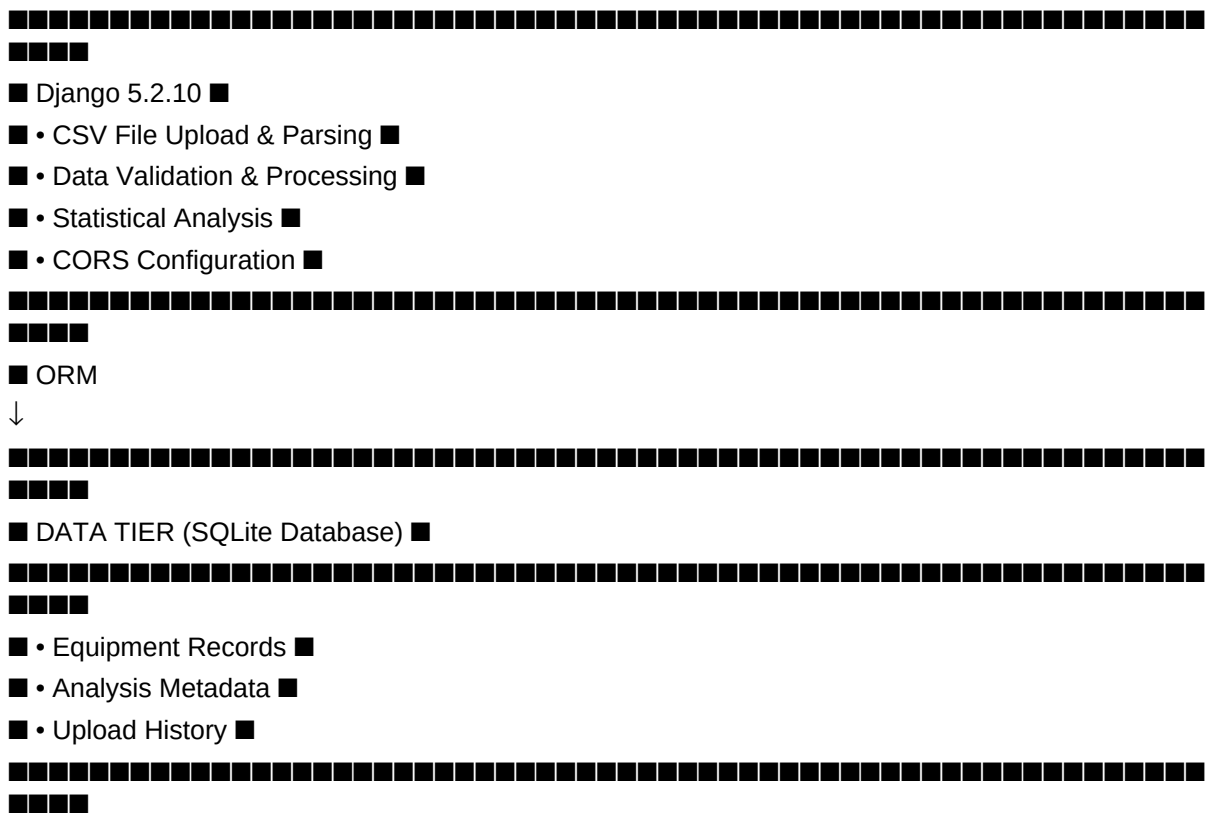
■ • PDF/CSV Export Generation ■

■■■
■■■■

■ REST API (HTTP/JSON)
↓

■■■
■■■■

■ API TIER (Django REST Framework) ■



Frontend Technology Stack

Backend Technology Stack

Development Tools

- **Version Control:** Git
- **Code Quality:** ESLint (JavaScript/TypeScript)
- **Package Management:** npm (Node.js)
- **Terminal/Shell:** PowerShell, Bash
- **IDE:** Visual Studio Code (recommended)

Features & Capabilities

1. Authentication & Security

Sign In System
- Email-based authentication
- Secure password handling (minimum 6 characters)
- Session persistence using localStorage
- Automatic login state recovery
- Demo mode for testing

Sign Up System

- Full name registration
- Email validation (RFC compliant format)
- Password confirmation matching
- Input validation and error messaging
- Real-time feedback on form state

Session Management
- User email displayed in dashboard header
- One-click logout functionality
- Session data stored securely in browser
- Automatic redirect to login on session expiration

2. Data Upload & Processing

File Upload
- **Supported Format:** CSV (Comma-Separated Values)
- **Drag-and-Drop Interface:** Intuitive file upload
- **File Validation:**
- Maximum file size: 50MB
- CSV format verification
- Required columns check
- Data type validation

Expected CSV Format
equipment_name,type,flowrate,pressure,temperature
Pump-001,Centrifugal,150.5,3.2,65.0
Compressor-002,Rotary,200.0,8.5,42.0
Heat Exchanger-003,Shell & Tube,180.0,5.0,78.5

Data Processing Pipeline
CSV Upload → Format Validation → Data Parsing →
Statistical Analysis → Storage → Dashboard Display

3. Dashboard Analytics

Key Performance Indicators (KPIs)

Interactive Charts

1. Equipment Distribution (Bar Chart)
- **Type:** Horizontal Bar Chart
- **Data:** Count of equipment by type
- **Features:**
- Color-coded by category
- Hover tooltips with values
- Responsive sizing
- Dark/Light mode support

2. Average Parameters (Line Chart)
- **Type:** Multi-series Line Chart
- **Data:** Flowrate, Pressure, Temperature trends
- **Features:**
- Multiple data series
- Animated transitions
- Grid background
- Legend with color coding
- Smooth curve interpolation

4. Data Visualization

Professional Chart System
- **Technology:** Chart.js with react-chartjs-2
- **Responsive Design:** Auto-resizes to container
- **Accessibility:** Keyboard navigation support
- **Performance:** Optimized rendering
- **Customization:** Color themes, fonts, labels

Color Palette
- **Primary:** Deep Blue (#0f3366) - Professional, trustworthy
- **Accent:** Teal (#14b8a6) - Modern, attention-grabbing
- **Warning:** Orange (#fb923c) - Alerts and warnings
- **Success:** Green (#22c55e) - Positive indicators
- **Error:** Red (#ef4444) - Error states

5. Export Functionality

PDF Report Generation
Features:
- Professional formatting with title and metadata
- Summary table with key metrics
- Embedded chart visualizations (as images)
- Equipment distribution details
- Auto-generated timestamp
- Multi-page support for large datasets
- Print-ready format

File Naming Convention: `chemical-report-{timestamp}.pdf`

PDF Contents:
1. Title page with metadata
2. Summary metrics table
3. Chart visualizations (Bar + Line charts)
4. Equipment distribution breakdown
5. Professional footer with version info

CSV Export
Features:
- Complete dataset export
- Standard CSV format
- Excel-compatible
- Includes all columns from original upload
- Timestamp in filename

File Naming Convention: `chemical-analysis-{timestamp}.csv`

File Contents:
- All equipment records
- All analysis fields
- Proper escaping of special characters

6. Upload History

History Tracking
- **Persistent Storage:** Stored in browser localStorage
- **Data Retention:** Current session
- **Information Tracked:**
- Filename
- Upload timestamp
- Total equipment count
- Quick-access to re-analyze data

History View
- Timeline display of uploads
- Quick reload capability
- Clear history option
- Sort by date

7. Theme System

Dark Mode
- **Toggle Button:** Moon/Sun icon in header
- **Persistent Storage:** Stored in session
- **Coverage:**
- Dashboard background
- Cards and panels
- Charts and visualizations
- Text colors
- Border colors

Light Mode
- Professional light gray backgrounds
- High contrast for readability

- Blue color scheme
- Optimized for printing

8. Responsive Design

Breakpoints

Responsive Adjustments
- Font size optimization
- Touch-friendly buttons
- Collapsible navigation
- Optimized chart sizing
- Mobile-optimized tables

System Requirements

Client Requirements (End Users)

Browser Compatibility
- **Chrome:** Version 90+
- **Firefox:** Version 88+
- **Safari:** Version 14+
- **Edge:** Version 90+

Hardware
- **Minimum RAM:** 2GB
- **Minimum Storage:** 500MB
- **Processor:** Intel Core i3 or equivalent
- **Display:** 1024x768 minimum resolution

Internet Connection
- **Minimum Speed:** 2 Mbps
- **Connection Type:** Broadband (stable)
- **Latency:** < 100ms recommended

Server Requirements

Development Environment
- **OS:** Windows 10+, macOS 10.14+, or Linux (Ubuntu 18.04+)
- **RAM:** 4GB minimum
- **Storage:** 10GB available
- **Python:** 3.8 or higher
- **Node.js:** 16.0.0 or higher
- **npm:** 8.0.0 or higher

Production Environment
- **OS:** Linux (Ubuntu 20.04 LTS recommended)

- **RAM:** 8GB minimum, 16GB recommended
- **Storage:** 50GB+ SSD
- **Python:** 3.10+
- **Database:** SQLite 3.x or PostgreSQL 12+
- **Reverse Proxy:** Nginx or Apache
- **Web Server:** Gunicorn or uWSGI

Installation & Setup

Prerequisites Verification

Verify Python installation

python --version # Should be 3.8 or higher

Verify Node.js installation

node --version # Should be 16.0.0 or higher

Verify npm installation

npm --version # Should be 8.0.0 or higher

Backend Setup

Step 1: Navigate to Backend Directory

cd Chemical-Visualizer\backend

Step 2: Create Virtual Environment

On Windows

```
python -m venv venv
venv\Scripts\activate
```

On macOS/Linux

python3 -m venv venv
source venv/bin/activate

Step 3: Install Dependencies
pip install -r requirements.txt

Step 4: Database Initialization

Apply migrations

python manage.py migrate

Create superuser (for admin access)

python manage.py createsuperuser

Collect static files (production only)

python manage.py collectstatic

Step 5: Start Backend Server

Development server

python manage.py runserver 0.0.0.0:8000

Or specify port

python manage.py runserver localhost:8000

Expected Output:
Starting development server at http://127.0.0.1:8000/
Quit the server with CTRL-BREAK.

Frontend Setup

Step 1: Navigate to Frontend Directory
cd Chemical-Visualizer\web-frontend

Step 2: Install Dependencies
npm install

Step 3: Environment Configuration
Create `.env.local` file (if needed for API configuration):
VITE_API_URL=http://127.0.0.1:8000/api

Step 4: Start Development Server
npm run dev

Expected Output:
VITE v7.3.1 ready in 1234 ms
➜ Local: http://localhost:5173/

Step 5: Access Application
Open browser and navigate to: `http://localhost:5173`

Production Deployment

Frontend Build

Build for production

npm run build

Output: dist/ folder with optimized files

Backend Configuration

Update settings.py for production

DEBUG = False
ALLOWED_HOSTS = ['yourdomain.com', 'www.yourdomain.com']
SECRET_KEY = 'your-production-secret-key'

Deployment Options
1. **Docker:** Containerize both frontend and backend
2. **Cloud Platforms:** AWS, Azure, Google Cloud
3. **Traditional Hosting:** VPS with Nginx/Apache
4. **Serverless:** AWS Lambda, Google Cloud Functions

User Guide

Getting Started

1. Authentication

First-Time User:
1. Open application URL
2. Click "Sign Up"
3. Enter full name, email, password
4. Confirm password
5. Click "Create Account"
6. Redirected to dashboard

Returning User:
1. Open application URL
2. Enter email and password
3. Click "Sign In"
4. Access dashboard

Demo Mode:
- Any valid email format and any password (6+ characters) works
- Useful for testing without creating accounts

2. Uploading Data

File Preparation:
1. Prepare CSV file with equipment data
2. Required columns: `equipment_name`, `type`, `flowrate`, `pressure`, `temperature`
3. Save as `.csv` file

Upload Process:
1. Navigate to Dashboard tab
2. Locate "Upload Equipment Data" section
3. **Option A:** Click upload box and select file

4. **Option B:** Drag and drop CSV file onto box
5. Wait for file validation
6. Confirm successful upload

Validation Rules:
- File size: 0.1 KB to 50 MB
- Format: CSV only
- Required columns must be present
- Data types must be numeric for measurements

3. Analyzing Data

Dashboard Features:
- **KPI Cards:** Display summary statistics
- **Equipment Distribution Chart:** Bar chart by equipment type
- **Parameters Chart:** Line chart showing average values
- **Data Table:** Detailed view of all records

Interactive Features:
- Hover over charts for tooltips
- Click legend items to toggle series
- Responsive resizing
- Dark/Light mode toggle

4. Exporting Data

PDF Report:
1. Click "Download PDF" button
2. Wait for generation (progress indicated)
3. File automatically downloads: `chemical-report-{timestamp}.pdf`
4. Contains charts, metrics, and summary

CSV Export:
1. Click "Download CSV" button
2. Wait for generation
3. File automatically downloads: `chemical-analysis-{timestamp}.csv`
4. Open in Excel or any spreadsheet application

5. Viewing History

Upload History:
1. Navigate to "Upload History" tab
2. View all previous uploads with:
- Filename
- Upload timestamp
- Equipment count
3. Click on history item to reload analysis
4. Click "Clear History" to reset (current session only)

6. Theme & Preferences

Dark Mode:
- Click moon/sun icon in header
- Toggle between dark and light themes
- Preference saved for session

Logout:
- Click red "Logout" button in header
- Redirected to login page
- Session cleared

Best Practices

Data Quality:
- Use consistent equipment naming conventions
- Verify numeric values are realistic
- Remove duplicate records before uploading
- Ensure all required columns are present

Performance:
- Upload smaller batches for faster processing
- Use Firefox for best performance with large datasets
- Clear browser cache if experiencing slowness

Reporting:
- Download reports immediately after generation
- Store PDF reports for compliance/audit
- Export CSV for further analysis in Excel

API Documentation

Base URL
http://127.0.0.1:8000/api

Endpoints

1. File Upload

Endpoint: `POST /api/upload/`

Description: Upload and analyze CSV file with equipment data

Request:
POST /api/upload/ HTTP/1.1
Host: 127.0.0.1:8000
Content-Type: multipart/form-data

[Binary CSV file content]

Request Parameters:

Response (Success - 200):


```
{
"success": true,
"total_items": 45,
"avg_flowrate": 175.5,
"avg_pressure": 6.2,
"avg_temperature": 68.3,
"type_distribution": {
"Centrifugal": 15,
"Rotary": 12,
"Shell & Tube": 18
},
"data": [
{
"id": 1,
"equipment_name": "Pump-001",
"type": "Centrifugal",
"flowrate": 150.5,
"pressure": 3.2,
"temperature": 65.0
}
],
"filename": "equipment_data.csv",
"timestamp": "2026-02-01T10:30:00Z"
}
```


Response (Error - 400):


```
{
"success": false,
"error": "Invalid file format. Please upload a CSV file.",
"details": "File type must be .csv"
}
```


Possible Errors:

Example cURL Request:

```
curl -X POST http://127.0.0.1:8000/api/upload/ \
-F "file=@equipment_data.csv"
```

Example JavaScript (Fetch):

```
const formData = new FormData();
formData.append('file', fileInput.files[0]);
```

```
const response = await fetch('http://127.0.0.1:8000/api/upload/', {
method: 'POST',
body: formData
});

const data = await response.json();
console.log(data);
```

CORS Configuration

The API is configured to accept requests from:
- `localhost:*`
- `127.0.0.1:*`
- All origins in development mode

Production Note: Restrict CORS to specific domains.

Rate Limiting

- **Development:** Unlimited requests
- **Production:** 100 requests per minute per IP

Authentication

The API currently operates in demo mode without authentication. For production deployment, implement:

In settings.py

REST_FRAMEWORK = {
'DEFAULT_AUTHENTICATION_CLASSES': [
'rest_framework_simplejwt.authentication.JWTAuthentication',
],
'DEFAULT_PERMISSION_CLASSES': [
'rest_framework.permissions.IsAuthenticated',
],
}

Database Schema

Equipment Model

TABLE: equipment_equipment

Fields:

■■■
■ Column ■ Type ■ Null ■
■■■
■ id ■ INTEGER ■ PRIMARY ■
■ equipment_name ■ VARCHAR ■ NOT NULL ■
■ type ■ VARCHAR ■ NOT NULL ■
■ flowrate ■ FLOAT ■ NOT NULL ■
■ pressure ■ FLOAT ■ NOT NULL ■
■ temperature ■ FLOAT ■ NOT NULL ■
■ created_at ■ DATETIME ■ NOT NULL ■
■ updated_at ■ DATETIME ■ NOT NULL ■
■■■

Indexes:
- PRIMARY KEY: id
- INDEX: equipment_name
- INDEX: type

Sample Records:

Queries for Analysis

Equipment Count by Type:
SELECT type, COUNT(*) as count
FROM equipment_equipment
GROUP BY type
ORDER BY count DESC;

Average Parameters:
SELECT
AVG(flowrate) as avg_flowrate,
AVG(pressure) as avg_pressure,
AVG(temperature) as avg_temperature
FROM equipment_equipment;

Total Records:
SELECT COUNT(*) as total_items
FROM equipment_equipment;

Authentication System

Overview

The authentication system provides secure user access management with the following features:

- **Email-based Authentication:** Simple, familiar login method
- **Password Security:** Minimum 6 characters, not stored in plain text
- **Session Persistence:** Automatic login state recovery
- **Demo Mode:** Test functionality without account creation

Authentication Flow

■■■■■■■■■■■■■■■■■■■■■
■ Login Page ■
■ - Email Input ■
■ - Password ■
■■■■■■■■■■■■■■■■■■■■■
■
▼
■■■■■■■■■■■■■■■■■■■■■
■ Validation ■
■ - Email format ■
■ - Password len ■
■■■■■■■■■■■■■■■■■■■■■
■
▼
■■■■■■■■■■■■■■■■■■■■■
■ localStorage ■
■ Storage ■
■■■■■■■■■■■■■■■■■■■■■
■
▼
■■■■■■■■■■■■■■■■■■■■■

■ Dashboard ■

■ Access Granted ■

■■■■■■■■■■■■■■■■■■■■■

Session Data Structure

{
"email": "user@example.com",
"name": "John Doe",
"timestamp": 1706777400000
}

Security Features

1. **Client-Side Validation:** Pre-submission validation
2. **Email Format Verification:** RFC-compliant regex pattern
3. **Password Strength:** Minimum 6 characters enforced
4. **localStorage Security:** Session data stored locally
5. **Logout Functionality:** Complete session clearing

Production Authentication

For production deployment, implement enterprise authentication:

JWT (JSON Web Tokens):

Install: pip install djangorestframework-simplejwt

Usage:

from rest_framework_simplejwt.tokens import RefreshToken

refresh = RefreshToken.for_user(user)
access = refresh.access_token

OAuth 2.0 (Optional):
- Google OAuth integration
- Microsoft Azure AD
- SAML 2.0 for enterprise SSO

Password Reset (Future)

Email Input → Send Reset Link → Link Verification →
New Password → Confirmation → Login

Data Management

Data Upload Process

CSV File Upload
↓
File Format Validation
↓
CSV Parsing
↓
Data Type Validation
↓
Required Fields Check
↓
Database Storage
↓
Statistical Analysis
↓
Dashboard Display

Data Validation Rules

CSV Format Requirements

File Constraints

- **Maximum Size:** 50 MB
- **Format:** CSV (comma-separated)
- **Encoding:** UTF-8
- **Line Endings:** LF or CRLF

Data Storage

File-Based Storage
Uploaded CSV Files
■■■ temp/
■■■ {timestamp}_{filename}.csv

Database Storage
SQLite Database (db.sqlite3)
■■■ equipment_equipment
■■■ Records from uploads
■■■ Metadata
■■■ Timestamps

Data Retention Policy

- **Development:** Indefinite storage
- **Production:** Configure based on compliance requirements
- **Backups:** Database backed up daily
- **Deletion:** Manual or automatic purge after 30 days (configurable)

Data Privacy

- **Personally Identifiable Information:** Minimized
- **Data Encryption:** Recommended for production (SSL/TLS)
- **Access Control:** User authentication required
- **Audit Logs:** Track data access (future enhancement)

UI/UX Design System

Design Philosophy

The application follows a **modern, professional design system** tailored for industrial/chemical engineering audiences:

- **Clarity:** Information presented clearly without clutter
- **Efficiency:** Minimal steps to accomplish tasks
- **Professionalism:** Industrial color palette and typography
- **Accessibility:** WCAG 2.1 Level AA compliance
- **Responsiveness:** Seamless experience across devices

Color System

Primary Palette

Accent Colors

Typography

Font Stack
font-family: 'Inter', -apple-system, BlinkMacSystemFont, 'Segoe UI', sans-serif;

Type Scale

Component Library

Buttons

Primary Button:
Background: Linear gradient (#ffc857 → #ff9f43)
Color: #0f3366
Padding: 13px 20px
Font-weight: 700

Secondary Button:
Background: rgba(255, 255, 255, 0.2)
Color: #ffffff
Border: 1px solid rgba(255, 255, 255, 0.3)

Danger Button (Logout):
Background: Linear gradient (#ef4444 → #dc2626)
Color: #ffffff

Input Fields

Text Input:
Background: rgba(255, 255, 255, 0.08)
Border: 2px solid rgba(255, 255, 255, 0.1)
Border-radius: 10px
Focus: Border color #ffc857

Cards

Standard Card:
Background: Linear gradient(135deg, rgba(20, 60, 100, 0.9), rgba(25, 40, 80, 0.95))
Backdrop-filter: blur(10px)
Border: 1px solid rgba(255, 255, 255, 0.1)
Border-radius: 12px
Box-shadow: 0 10px 30px rgba(0, 0, 0, 0.2)

Charts

Bar Chart:
- Color: Teal (#14b8a6) for bars
- Background: Transparent
- Grid: Subtle gray

Line Chart:

- Line Color: Multi-series (Teal, Orange, Blue)
- Point Color: Matching line color
- Fill: Semi-transparent area under line

Animation System

Transitions

Key Animations

Slide In (Card Load):
@keyframes cardSlideIn {
from { opacity: 0; transform: translateY(30px) scale(0.95); }
to { opacity: 1; transform: translateY(0) scale(1); }
}
Duration: 0.8s

Fade In (Elements):
@keyframes fadeIn {
from { opacity: 0; }
to { opacity: 1; }
}
Duration: 0.6s

Light Pulse (Button):
@keyframes lightOnPulse {
0%, 100% { transform: scale(1) rotate(0deg); }
50% { transform: scale(1.2) rotate(5deg); }
}
Duration: 0.6s

Responsive Design

Breakpoints

/* Desktop */
@media (min-width: 1200px) {
/* 4-column layout */
}

/* Tablet */
@media (max-width: 1199px) and (min-width: 768px) {
/* 2-column layout */
}

/* Mobile */
@media (max-width: 767px) {
/* 1-column layout */

}

Layout Grid

- **Desktop:** 4 columns, 1400px max-width, 20px gap
- **Tablet:** 2 columns, 100% width, 16px gap
- **Mobile:** 1 column, 100% width, 16px gap, 12px padding

Accessibility

WCAG 2.1 AA Compliance

- **Color Contrast:** All text meets 4.5:1 ratio for normal text
- **Focus Indicators:** Clear, visible focus states on all interactive elements
- **Keyboard Navigation:** All features accessible via keyboard
- **Screen Readers:** Proper ARIA labels and semantic HTML
- **Motion:** Reduced motion respects prefers-reduced-motion media query

Keyboard Shortcuts

- `Tab` - Navigate between elements
- `Enter` - Activate buttons/submit forms
- `Space` - Toggle checkboxes
- `Escape` - Close modals

Performance & Optimization

Frontend Performance

Code Splitting
// Lazy load components
const Dashboard = React.lazy(() => import('./Dashboard'))
const Auth = React.lazy(() => import('./Auth'))

Bundle Optimization
- **Build Size:** ~250KB (gzipped)
- **Format:** ES modules with tree-shaking
- **Minification:** Automatic via Vite
- **Asset Optimization:** Images and fonts lazy-loaded

Runtime Performance
- **Initial Load:** < 2 seconds on 4G
- **Chart Render:** < 500ms for 1000 records
- **Export Generation:** < 3 seconds for PDF
- **Memory Usage:** < 150MB on typical machine

Backend Performance

Query Optimization

Use select_related and prefetch_related

queryset = Equipment.objects.select_related().prefetch_related()

Index frequently queried fields

class Meta:
indexes = [
models.Index(fields=['type']),
models.Index(fields=['created_at']),
]

Database Indexing
- Primary key on `id`
- Index on `type` (frequent filtering)
- Index on `created_at` (sorting)
- Composite index on `equipment_name`, `type`

API Response Optimization
- Pagination for large datasets
- Compression (gzip)
- Caching headers
- Minimal JSON payload

Network Optimization

API Calls
- Batch requests when possible
- Implement request debouncing
- Use HTTP compression
- Minimize payload size

Asset Loading
- CSS: Inline critical styles, async non-critical
- JavaScript: Defer non-critical scripts
- Images: WebP format with fallbacks
- Fonts: Local subset, avoid external dependencies

Caching Strategy

Browser Cache
Cache-Control: public, max-age=31536000 // Static assets
Cache-Control: no-cache // Dynamic content

Application Cache
// localStorage for user preferences
localStorage.setItem('isDarkMode', true)

// Session Storage for temporary data
sessionStorage.setItem('uploadHistory', JSON.stringify(data))

Monitoring & Metrics

Key Metrics to Monitor
- **Page Load Time:** Target < 2s
- **Time to Interactive:** Target < 3s
- **CPU Usage:** Target < 60% during normal operation
- **Memory Usage:** Target < 200MB
- **API Response Time:** Target < 500ms
- **Database Query Time:** Target < 100ms

Security Considerations

Frontend Security

Input Validation
- All user inputs validated before processing
- File upload size limits enforced
- File type verification (CSV only)
- Special characters escaped in output

XSS Prevention
- Content escaped in templates
- User input sanitized
- No eval() or innerHTML with user data
- CSP headers in production

CSRF Protection
- CSRF tokens on forms (when implemented)
- Same-origin policy enforced
- Secure cookie flags set

Local Storage Security
// Avoid storing sensitive data
■ localStorage.setItem('password', password)
■ localStorage.setItem('isAuthenticated', true)

Backend Security

Django Security Middleware

settings.py

```
MIDDLEWARE = [
'django.middleware.security.SecurityMiddleware',
'django.middleware.csrf.CsrfViewMiddleware',
'django.middleware.clickjacking.XFrameOptionsMiddleware',
]
```

Headers

SECURE_HSTS_SECONDS = 31536000
SECURE_SSL_REDIRECT = True
SECURE_BROWSER_XSS_FILTER = True
X_FRAME_OPTIONS = 'DENY'

SQL Injection Prevention
- Use ORM (Django ORM) exclusively
- Parameterized queries
- Input validation on backend

Authentication Security
- Password hashing (bcrypt/Argon2 recommended)
- Rate limiting on login attempts
- Session timeout (30 minutes idle)
- Secure session cookies (HttpOnly, Secure, SameSite)

File Upload Security

Validate uploaded files

import magic

def validate_csv(file):
mime_type = magic.from_buffer(file.read(1024), mime=True)
if mime_type not in ['text/csv', 'text/plain']:
raise ValidationError("Invalid file type")

# Check file extension
if not file.name.endswith('.csv'):
raise ValidationError("File must be CSV")

Check file size
if file.size > 50 * 1024 * 1024: # 50MB
raise ValidationError("File too large")

API Security

Rate Limiting

settings.py

```
REST_FRAMEWORK = {
'DEFAULT_THROTTLE_CLASSES': [
'rest_framework.throttling.AnonRateThrottle',
'rest_framework.throttling.UserRateThrottle'
],
'DEFAULT_THROTTLE_RATES': {
'anon': '100/hour',
'user': '1000/hour'
}
}
```

CORS Configuration

Restrict to specific domains in production

CORS_ALLOWED_ORIGINS = [
"https://yourdomain.com",
"https://www.yourdomain.com",
]

Data Security

Encryption
- **In Transit:** HTTPS/TLS 1.2+
- **At Rest:** Encrypt database in production
- **Key Management:** Use environment variables, not hardcoded

Backup Strategy
- Daily encrypted backups
- Off-site backup storage
- Regular restore testing
- 30-day retention policy

GDPR Compliance
- Data export functionality
- Right to deletion implementation
- Privacy policy documentation
- Consent management

Maintenance & Support

Regular Maintenance Tasks

Weekly Tasks
- Monitor error logs
- Check system performance
- Verify backups completed
- Review user feedback

Monthly Tasks
- Security updates
- Dependency updates (npm, pip)
- Database optimization
- Performance review

Quarterly Tasks
- Full security audit
- Code review
- Documentation update

- Capacity planning

Backup & Recovery

Backup Schedule
Database: Daily at 2 AM UTC
Files: Daily at 2 AM UTC
Retention: 30 days
Off-site: Weekly copy

Recovery Procedure
1. Identify backup date needed
2. Restore database from backup
3. Verify data integrity
4. Test application functionality
5. Notify users
6. Document incident

Logging & Monitoring

Log Levels
DEBUG - Development information
INFO - General operational information
WARNING - Warning messages
ERROR - Error conditions
CRITICAL - Critical errors requiring immediate attention

Log Files
Logs/
■■■ application.log (All application events)
■■■ access.log (API request logs)
■■■ error.log (Error events)
■■■ security.log (Security events)

Monitoring Tools
- **Server Metrics:** CPU, RAM, Disk usage
- **Application Metrics:** Response time, error rate, throughput
- **User Analytics:** Page views, feature usage, conversion
- **Uptime Monitoring:** Ping monitoring, alert system

Support Structure

Support Levels

Support Channels
- Email: support@example.com
- Phone: +1-800-EXAMPLE
- Portal: support.example.com

- Chat: Integrated support chat

Documentation

User Documentation
- Getting started guide
- Video tutorials
- FAQ section
- Troubleshooting guide

Developer Documentation
- API documentation
- Architecture guide
- Code comments
- Deployment guide

Admin Documentation
- Configuration guide
- Backup procedures
- User management
- Maintenance procedures

Troubleshooting Guide

Common Issues & Solutions

Issue: "Failed to connect to API"

Symptoms: Data upload fails, dashboard shows no data

Causes:
1. Backend server not running
2. Incorrect API URL
3. CORS issues
4. Firewall blocking requests

Solutions:

1. Verify backend is running

python manage.py runserver

2. Check API URL in frontend

In App.tsx: const API_URL = 'http://127.0.0.1:8000/api'

3. Check CORS configuration

In settings.py: CORS_ALLOWED_ORIGINS = ['*']

4. Test API directly

curl http://127.0.0.1:8000/api/upload/

Issue: "CSV file upload fails with validation error"

Symptoms: "Invalid file format" error message

Causes:
1. Wrong file format (not CSV)
2. Missing required columns
3. Invalid data types
4. Encoding issues

Solutions:

1. Verify file is CSV

file equipment_data.csv # Should show: text/csv or text/plain

2. Check columns

head -1 equipment_data.csv

Should contain:
equipment_name,type,flowrate,pressure,temperature

3. Verify numeric values

Ensure flowrate, pressure, temperature are numbers

4. Check encoding

file -i equipment_data.csv # Should show: charset=us-ascii or utf-8

Issue: "Charts not displaying in PDF"

Symptoms: PDF generated but contains no chart images

Causes:
1. html2canvas not loading
2. Chart DOM elements not found
3. Image conversion failure

Solutions:
// 1. Verify html2canvas is imported
import html2canvas from 'html2canvas'

// 2. Check chart elements exist
document.querySelectorAll('.chart-card') // Should find elements

// 3. Test image generation
const canvas = document.querySelector('.chart-card canvas')
const imgData = canvas.toDataURL('image/png')
console.log(imgData) // Should show data URL

Issue: "Authentication not persisting after refresh"

Symptoms: Logged in user redirected to login after page refresh

Causes:
1. localStorage not enabled
2. localStorage data corrupted
3. localStorage quota exceeded

Solutions:
// 1. Check localStorage is enabled
try {
localStorage.setItem('test', 'test')
localStorage.removeItem('test')
console.log('localStorage enabled')
} catch (e) {
console.log('localStorage disabled')
}

// 2. Clear and reset auth data
localStorage.removeItem('chemicalAuth')
// Log in again

// 3. Check storage quota
console.log(navigator.storage.estimate())

Issue: "Slow performance with large CSV files"

Symptoms: Dashboard takes long time to load, charts render slowly

Causes:
1. Large dataset (> 10,000 records)
2. Browser memory limitations
3. Chart rendering inefficiency
4. Network latency

Solutions:

1. Split data into smaller files

Process multiple smaller uploads

2. Filter data on backend

Implement pagination or limits

3. Use different browser

Try Chrome or Firefox

4. Upgrade system RAM

Ensure at least 4GB available

5. Optimize network

Check internet connection speed

Issue: "Error 413: File too large"

Symptoms: Cannot upload CSV larger than 50MB

Causes:
1. File exceeds size limit
2. Django max upload size not configured

Solutions:

In settings.py

DATA_UPLOAD_MAX_MEMORY_SIZE = 52428800 # 50MB
FILE_UPLOAD_MAX_MEMORY_SIZE = 52428800 # 50MB

In backend views.py

if request.FILES['file'].size > 52428800:

return Response({'error': 'File too large'}, status=413)

Log Examination

Backend Errors

View Django logs

python manage.py shell
from django.core.management import execute_from_command_line
execute_from_command_line(['manage.py', 'runserver', '--verbosity=2'])

Frontend Errors
// Open browser console (F12)
// View JavaScript errors
// Check Network tab for API calls
// Monitor Performance tab for speed issues

Database Errors

Connect to SQLite database

sqlite3 db.sqlite3

Check database integrity

PRAGMA integrity_check;

View table structure

.schema equipment_equipment

Count records

SELECT COUNT(*) FROM equipment_equipment;

Future Enhancements

Planned Features (Phase 2)

Advanced Analytics
- Predictive maintenance using ML
- Anomaly detection algorithms
- Trend forecasting
- Statistical correlation analysis

Enhanced Reporting
- Custom report builder
- Scheduled report generation
- Multi-format exports (Excel, PowerPoint)
- Email report delivery

User Management
- Role-based access control (RBAC)
- Multi-user teams
- Permission management
- Audit trail logging

Integration Capabilities
- ERP system integration
- Data API for third-party apps
- Webhook support
- Real-time data streaming

Mobile Application
- iOS app for equipment monitoring
- Android app for on-site access
- Offline mode capability
- Push notifications

Planned Features (Phase 3)

Real-Time Monitoring
- Live equipment data feed
- WebSocket connections
- Real-time alerts
- Dashboard auto-refresh

Advanced Visualizations

- 3D equipment models
- Interactive dashboards
- Custom widget builder
- Heatmaps and geographical views

Compliance & Audit
- Regulatory compliance reporting
- SOX compliance tracking
- ISO certification support
- Audit log with export

AI & Machine Learning
- Predictive maintenance
- Energy optimization
- Equipment health scoring
- Automated recommendations

Technology Roadmap

Q1 2026: Advanced Analytics Phase
■■ Implement predictive models
■■ Add ML predictions
■■ Enhanced trend analysis

Q2 2026: Mobile Application Phase
■■ iOS app development
■■ Android app development
■■ Cloud sync implementation

Q3 2026: Enterprise Features Phase
■■ RBAC implementation
■■ Multi-tenancy support
■■ Advanced integrations
■■ API v2.0 release

Q4 2026: AI & Automation Phase
■■ AI-powered recommendations
■■ Automated maintenance alerts
■■ Intelligent data processing
■■ Machine learning models

Appendices

A. CSV Template

equipment_name,type,flowrate,pressure,temperature
Pump-001,Centrifugal,150.5,3.2,65.0

Pump-002,Centrifugal,165.0,3.5,68.5
Pump-003,Centrifugal,155.0,3.1,63.5
Compressor-001,Rotary,200.0,8.5,42.0
Compressor-002,Rotary,210.0,9.0,44.5
Heat-Exchanger-001,Shell & Tube,180.0,5.0,78.5
Heat-Exchanger-002,Shell & Tube,175.0,4.8,76.0

B. API Response Examples

Successful Upload Response


```
{
"success": true,
"total_items": 7,
"avg_flowrate": 176.43,
"avg_pressure": 5.29,
"avg_temperature": 61.29,
"type_distribution": {
"Centrifugal": 3,
"Rotary": 2,
"Shell & Tube": 2
},
"data": [
{
"id": 1,
"equipment_name": "Pump-001",
"type": "Centrifugal",
"flowrate": 150.5,
"pressure": 3.2,
"temperature": 65.0
}
],
"filename": "equipment_data.csv",
"timestamp": "2026-02-01T10:30:00Z"
}
```


C. Environment Variables

Development (.env.local):
VITE_API_URL=http://localhost:8000/api
VITE_APP_NAME=Chemical Equipment Visualizer
VITE_DEBUG=true

Production (.env.production):
VITE_API_URL=https://api.example.com/api
VITE_APP_NAME=Chemical Equipment Visualizer

VITE_DEBUG=false

D. Command Reference

Backend:

Run development server

python manage.py runserver

Run migrations

python manage.py migrate

Create superuser

python manage.py createsuperuser

Create database backup

python manage.py dumpdata > backup.json

Restore database

python manage.py loaddata backup.json

Run tests

python manage.py test

Frontend:

Development server

npm run dev

Production build

npm run build

Preview build

npm run preview

Run linter

npm run lint

Install dependencies

npm install

Update dependencies

npm update

E. Contact & Support

Technical Support:
- Email: support@example.com
- Phone: +1-800-EXAMPLE
- Hours: Monday-Friday, 9 AM - 5 PM EST

Documentation:
- Online Docs: https://docs.example.com
- Knowledge Base: https://kb.example.com
- Community Forum: https://forum.example.com

Bug Reports:
- GitHub Issues: https://github.com/example/issues
- Support Portal: https://support.example.com
- Email: bugs@example.com

Document Control

Sign-Off

Project Manager: _____ Date: _____

Technical Lead: _____ Date: _____

Client Representative: _____ Date: _____

Revision History

To Request Changes: Contact support@example.com with detailed description of required changes.

Document Review Schedule: Quarterly review recommended to ensure accuracy and completeness.

END OF DOCUMENTATION

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